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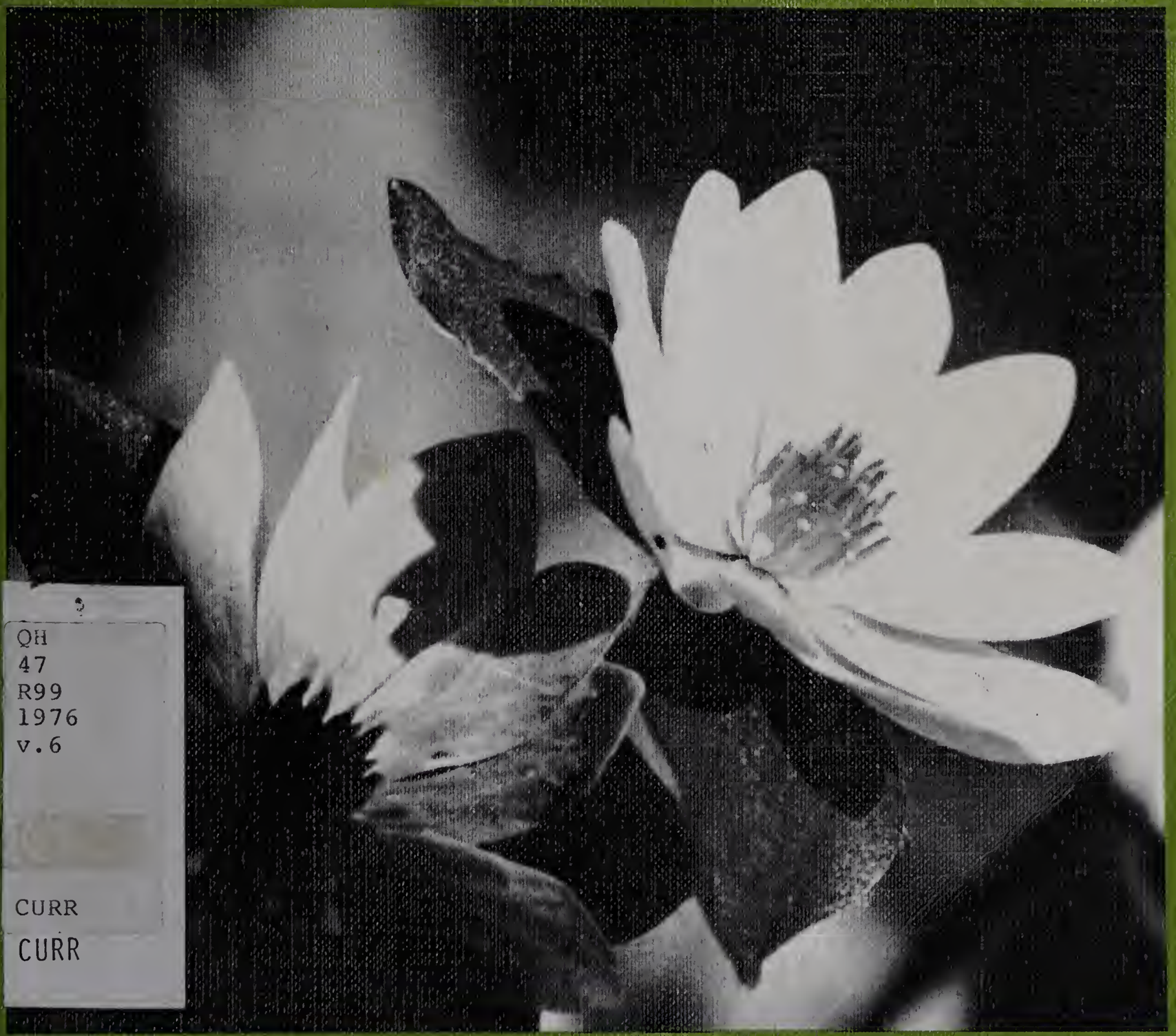
Studying Plants

METRIC EDITION

Doug Sadler



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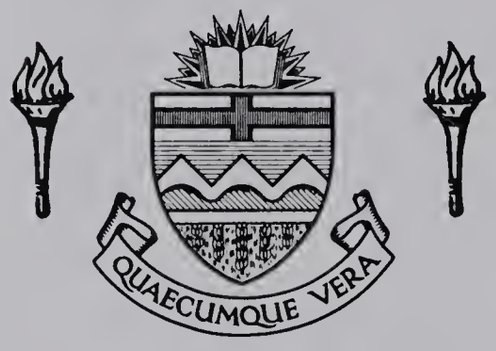

Studying Plants

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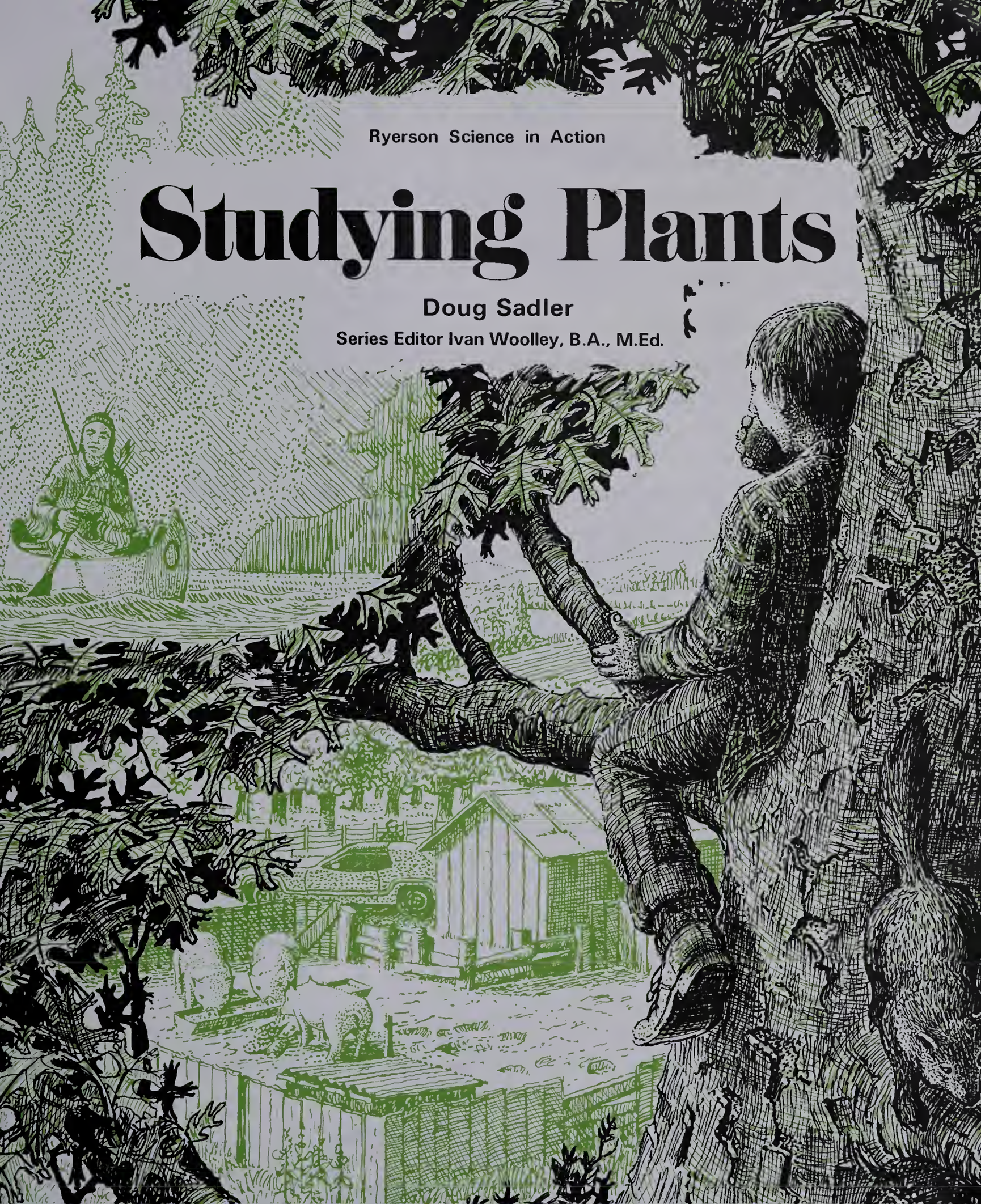
Ryerson Science in Action

Studying Plants

Doug Sadler

Series Editor Ivan Woolley, B.A., M.Ed.



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The author is an outdoor education consultant, and a past president of the Federation of Ontario Naturalists. His weekly outdoors column appears in the *Peterborough Examiner*.

NOTE: *This symbol indicates an activity.*

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INTRODUCTION

"I like animals," said the boy, crunching his teeth into an apple, "but plants are boring. Who wants to know about them!"

He cut through the old orchard to avoid the hot hardness of the road. The grass was soft but uneven. It was a gay place with patches of goldenrod and purple asters, and the boy felt happy. For supper he knew there would be pork chops from his uncle's pig, fattened on the corn cobs he had helped pick. But the twisted old tree just had to be climbed, right then.

The bark was rough with age, but the stout cotton of his old jeans was still able to protect him. Soon he sat astride his favourite branch, high above the billowing sea of green. He was an Indian in a birch canoe, paddling quietly through the trackless forest. His boat crept carefully past a big bull moose—or was it a cow? A pine marten scurried among the branches. It looked remarkably like the old grey cat from the farm. This wilderness might be a bit spooky, but it certainly had lots of interest.

But being up on the cross-arm of a sailing schooner was even more thrilling. The great whitepine mast swung back and forth across the sky with him. It could have come from his uncle's farm in New Brunswick! Hearts of oak made the ship below him and hearts-of-oak were the men who sailed them. . . .

"Teddy! Supper!"

The old billy goat chewed on a twig and stared at him as he ran home. But the goat was thinking of the forests its ancestors had browsed away in North Africa, and the deserts they had made.

This is a science book. Does that mean you have to wear a white coat, or work in a laboratory? Of course not. You don't even have to be in school for it, because science just means *knowing*. Knowing is fun. But it is not always as

simple as it sounds. Let us look at it for a moment. Perhaps the best way to understand it is to look at what it is *not.*

Knowing is not opinion. Just thinking or believing is not enough. A scientist knows something because he can prove it is true.

Knowing is not prejudice. Prejudice means making up your mind beforehand. Just because something seems to be so, or because we would like it to be so, doesn't make it true. A scientist does not take things for granted.

Knowing is not what someone else said or wrote. Science is concerned with facts.

Knowing is not just facts, however. A whole bagful of mixed facts is worth far less than just a few carefully fitted together. It's like a jigsaw puzzle. Science tries to make a pattern out of the facts it discovers, for only then do they mean much to us.

Knowing comes from asking the right questions and working hard to find the right answers.

Knowing takes self-discipline. It has certain rules. Examples are: to measure accurately; to observe carefully; to know the importance of having adequate samples, of using controls, and of identifying variables. This sounds difficult. But it is interesting. This book will help you to find out about these things.

Knowing is fun. The more you know the more fun it is. Knowing and finding out do not stop at 15 50 when the bell goes. They don't take a holiday from the end of June to the beginning of September. The fun keeps on all the time.

This book is about plants. Many of the most interesting things about them take place during the summer, when school is out. Some experiments you do may run over into the school holidays. Keep this book handy, so you can go on with your finding out all the time. If you do it right, you are being a real scientist. Most of the activities do not need much equipment and you can make some of it yourself.

Chapter 1

PLANTS IN OUR LIVES

This is a book about plants. It is therefore a very important book indeed, because plants are important. They are not only useful, but also necessary to all animals on earth. They grow in one form or another everywhere in the world, even the arctic and the deserts, the oceans and the cities.

This book will take us on a journey through a lot of territory. Before we start, it will be encouraging to see how much we know already about plants and the part they play in our lives. You will probably be surprised by how much you know.

Make a list of as many different kinds of plants as you can. Think of large ones, 35 metres and more tall, and tiny ones you can hardly see with your eye. Think not only of your own country but also of others. Work on this list in your spare time. It would be interesting to make it without looking at books. You will be amazed at how many names you write down.

Did you find that you wanted to make this list under headings? Did this idea make it easier to think of items?

Look in your home for examples of plants being used. Visit a supermarket; find products there which use plants in one way or another.

Sometimes it is hard to tell. Paints may be made of oils or rubber from plants. Some plastics are made from plant materials. Try to find out about these things. Where?

Look in the library.
Ask people in the stores and elsewhere.
Write to companies.

Find out how trees are used in your part of the country. Use general terms. It is not necessary to list all the kinds of furniture or the sizes of construction lumber. Trees are

useful for many things besides wood. Think of food, drink, breathing, soil, weather, wildlife uses of forests, recreation. You may find other headings.

What jobs depend on the forests? This book is itself one clue. You can add to your knowledge of plants in many ways. This book will suggest many. Here are a few general suggestions, designed to increase your familiarity with them and to make what follows easier. You could do these at any time before, during, or after your studies. But the sooner the better.

Grow plants. It does not matter much what kinds they are, or whether they are grown in a dish or pot on the classroom window sill, in a school garden plot, or at home. The important thing is to take care of them and to watch them carefully. Describe accurately all the things that happen when a bean becomes a bean plant; when it flowers; when it sets seed.

You can grow plants *vegetatively* (not from seed, but from part of a plant) in the following ways:

Cut off the top of a fresh pineapple.
Cut about 1 cm off the top of a carrot.
Use a chunk of sweet potato, being sure to include an "eye" (bud).

Set these in a saucer (or other shallow utensil). Keep watered.
A fine indoor plant can be grown from an avocado pit. Compressed cubes of plant *nutrients,* which expand when water is added, can be bought. ("Jiffy 7" is one name).

Some schoolchildren have cooked meals using foods they have raised themselves. It is quite an experience.

Visit places where plants are grown or processed. Here are a few suggestions:

farms
gardens
pulp mill
grain elevators
fruit canneries
printing shop

greenhouse
sawmill
banana boat
florist
apple storage plants
peanut-butter factory
house being built
farm research centre
fruit and vegetable store or department

You will find many examples around you. Ask your teacher or your parents to arrange such visits for you, or you may be able to do so yourself in some cases, when the owner is known to you.

Learn to think of all the questions you can ask: Where does the raw material come from? How does it come and why? How many different products are made or grown? How many people work there? What is their work like? What machinery is used? How much does it cost? Where is it made? Where is the product sold? How is it sent? Does special care have to be taken in packaging, speed of delivery, temperature? What are the main problems of the business? and many more.

It does not matter where you go, you will find fascinating pieces of information.

THE PLANTS OF CHRISTMAS

(This class project can be done at any stage, but goes better after some other plant study has been done.)
Object of this activity is to "sell" your plant against all the others. This is how it goes:

1. Working all together, the class should make a list of plants associated in some way with Christmas.
   Here is a list made by one classroom. (You will perhaps be able to think of some others.)
   Someone suggested that the turkey was really a plant since it was made entirely out of the plants it ate!
2. Working in teams (perhaps pairs), try to find out as many interesting facts as you can about *your* plant. Each team has a different plant.
   Here are some suggestions as to what you should look for:
   Facts about the plant itself that you find new and interesting; you might use the microscope.

Scientific principles illustrated by the plant—adaptation to dry conditions, or wet; where it will grow and why; how it reproduces; etc.

Plant relatives worth mentioning; do any grow near where you live?

History of man's use of the plant; how he has changed it; how people make a living from the plant.

Stories and legends about the plant.

There are really interesting things to find out about all the plants on the list, if you look for them.

3. Next comes the talent show, where you try to prove that your plant is more interesting than all the others.

   Your team must find a way of convincing the rest of the class. Think of yourself as a salesman. You must be clear and interesting; you must remember how much your audience knows already. Use slides, models, magnified diagrams, charts, playlets, songs, anything to keep your customers' attention and to involve them with your presentation.

4. Everyone has three votes. He puts down what he thinks are the best three in order. First place gets 3 marks, second gets 2, third gets one. (This gets around the chance that everyone will vote for his own plant first!)

PLANTS IN THE ARTS

Plants have always been used in art. Gardens are a kind of artwork. Sometimes these are sort of "natural"; others may

Graceful branches of the willow may have inspired the mosaics often found in Islamic buildings.

be designed down to the last detail in artificial patterns. What do we call people who do this kind of work?

The lotus (a kind of water lily) has been used as a decoration in buildings for thousands of years—since the days of Ancient Egypt. New Englanders used the pineapple design in their houses as a sign of hospitality. The gracefully curving branches of willows have inspired mosaics on Eastern mosques. The shape of trees has inspired many famous pictures. We set up Christmas trees, and use holly and poinsettias widely in decoration at one time of year.

In this book there are many suggestions for artwork based on plants (page 101). Here are some basic ideas:

1. Collect coloured leaves in Fall. Try to match the colours, using only the three primary colours, plus black and white. Be as exact as you can.
2. Make bark rubbings, using different colours of crayons. Combine these; overlap them; play with them.
3. Look for examples of the elements of design in nature:

colour
- —masses
- —primary and secondary colours; various shades and tints of one colour; contrasting and blending colours

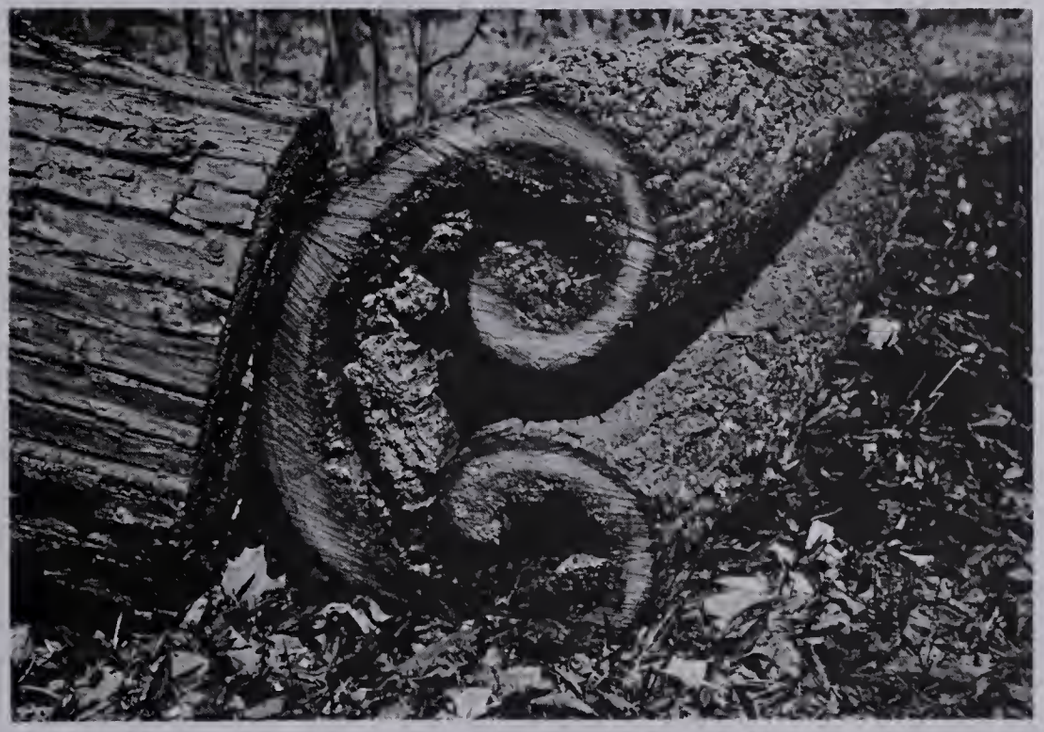
textures
- —smoothness, hairiness, roughness, grooves, softness and hardness
- —textured patterns—network veining on some flower petals (salpiglossis, henbane), leaves (rattlesnake plantain)
- —leaf patterns against the sky

lines
- —vertical, horizontal, slanting
- —straight, curving, criss-crossing

shapes
- —geometric shapes in flowers, seed cases, leaves
- —odd, grotesque, funny shapes
- —repeated shapes, lines, patterns

The Skunk Cabbage bloom is seen early in Spring, before the leaves; it attracts early carrion insects looking for animals that died during the winter, so the plant has a dead-flesh colour and odour.

Beautiful patterns are everywhere. The centre of this tree died, but the living layers tried to heal the opening.



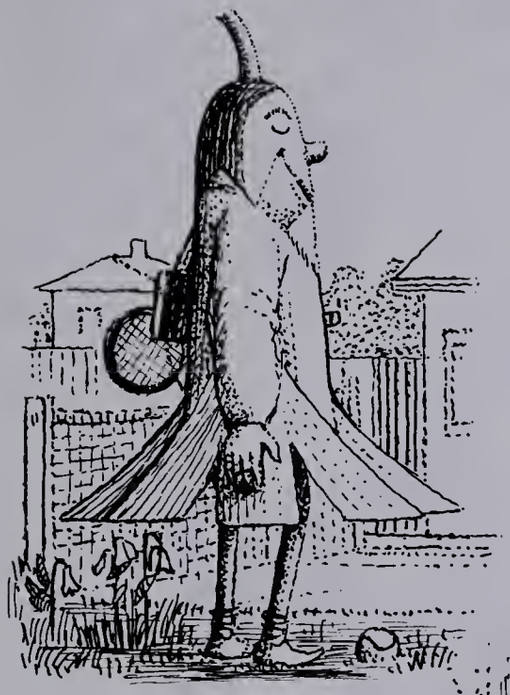
You will not be surprised by now to learn that none of these things comes by accident. The colour, shape, position of a flower, a stem, a whole plant are the result of conditions and needs of the plant's life.

Track down some of these. Why does a tree usually grow straight up? Look at the shoots of wild leek or other early woodland plants forcing up through the frozen snow or soil. What shape are they? Why are the branches, twigs and leaves of a tree arranged in the way they are? Why is there so often a patch of a different colour in the centre of a flower?

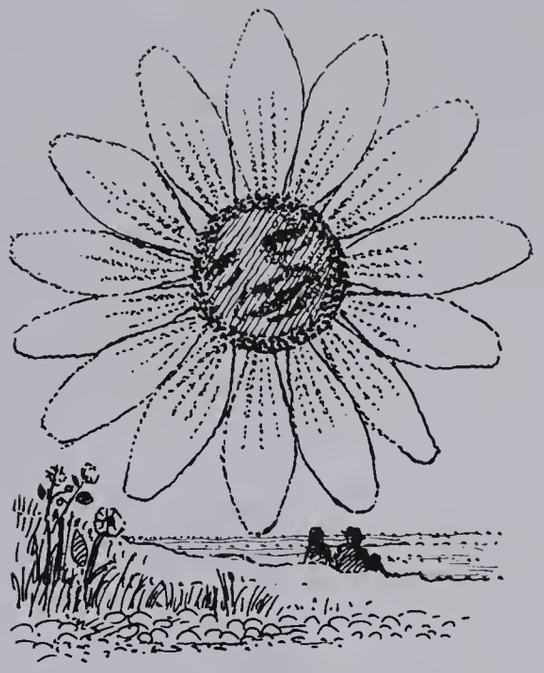
4. Make collage pictures, using natural plant materials.
5. Dry flowers for use in winter. Some flowers will dry well if you just hang them up in a dry cool, dark place for a while. Others will shrivel up, so need special treatment.

   Mix 600 g of corn meal with 200 g of borax. Put the plant on a layer of the mixture and cover it well with the remainder. Keep cool and dry. Leave for 3 weeks. Leaves will fall off but the flower will retain colour and shape. Don't dry too long. Marigolds, pansies, zinnias, mums and asters are all good. Experiment.
6. Use clear plastic to embed seeds. (See *Studying Insects.)*
7. Making and using natural dyes is a fascinating and harmless hobby. Many wild plants, and others easily bought, can be used. Some examples are onion skin, goldenrod, black currant, black-eyed susan, some lichens, butternut, alder. A number of different chemicals are used to "set" the colour—to make it "fast" so that it will not run or wash out in the laundry and will not fade in the sun. Pioneers did this all the time.
8. Draw the main outlines of different flowers, perhaps from different angles (front, side, half rear even). You can take these from a book, or even better from living plants.

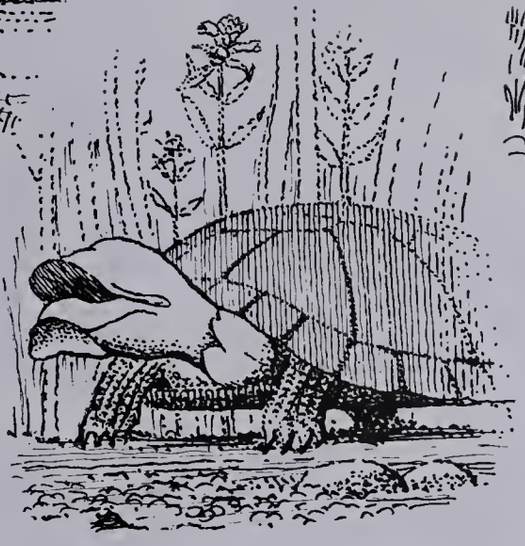
   Now try to make each drawing into a person or animal, perhaps only the face, but maybe more. Easy examples are dandelion, turtlehead, fuchsia.



Fuchsia

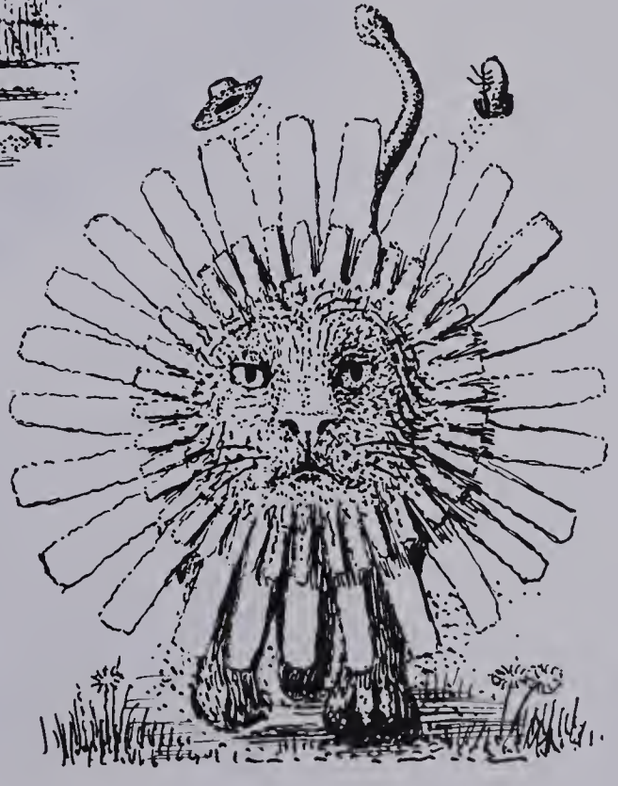


Sunflower



Turtlehead

Apple



Dandelion

INK PAD PRINTS

You will need:
ink pad
white paper or note book
many scraps of newspaper slightly larger than your leaves

Lay leaf vein side down on ink pad.
Cover with scrap of paper, rub hard.
Transfer leaf, ink side down, to white paper.
Cover with fresh scrap of paper.
Rub hard being careful not to move the leaf.
Note: To do a neat job, keep waste paper basket handy and throw away each inky specimen and scrap of paper as you use it.

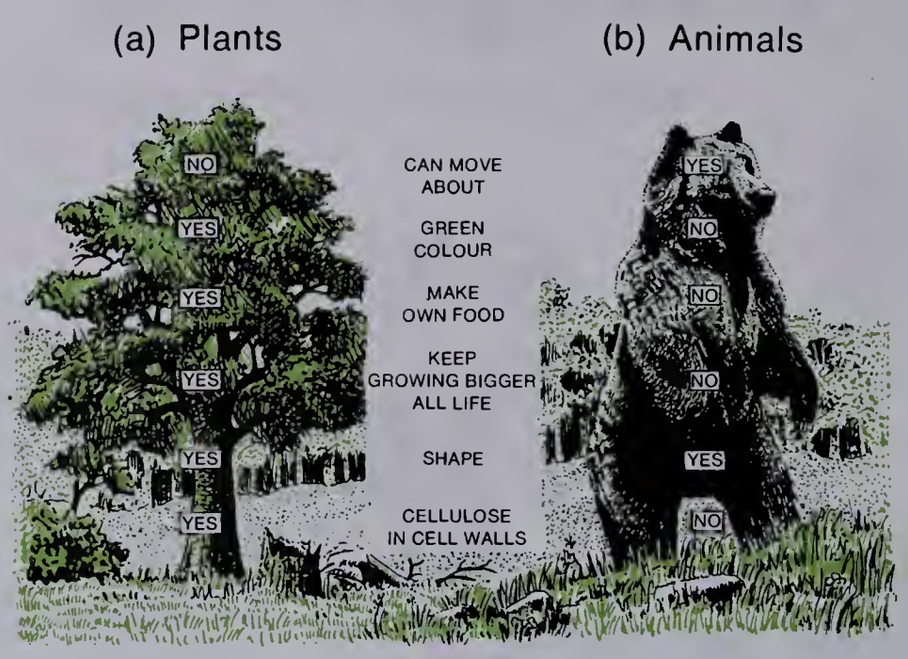
CRAYON PRINTS

You will need:
piece of crayon peeled, paper (newsprint is inexpensive and works best.)
Place leaf smooth side down on flat surface.
Cover with piece of newsprint.
Hold paper securely.
Rub with whole **side** of crayon.
Make a rubbing of entire stem and mid rib. Once this guide line is established bring out the whole pattern of the leaf blade by firmly rubbing from the mid rib out to the leaf edge.
Cut out and mount in your notebook.
If you have made a rubbing of a bristle-tipped leaf, add tips with crayon point after cutting and mounting.

Chapter 2

WHAT IS A PLANT?

We have already considered plants in a number of ways. It seems odd to be asking now what a plant is. In fact, there is no fail-safe answer, only near-enough ones. The world is a varied and complicated place. We try to make sense out of it by inventing patterns and compartments. We divide living things (see Chapter 5) into the Animal Kingdom and the Plant Kingdom. *Most living things fit either the one or the other.* But not all. There are always, it seems, *exceptions.*



NOTES

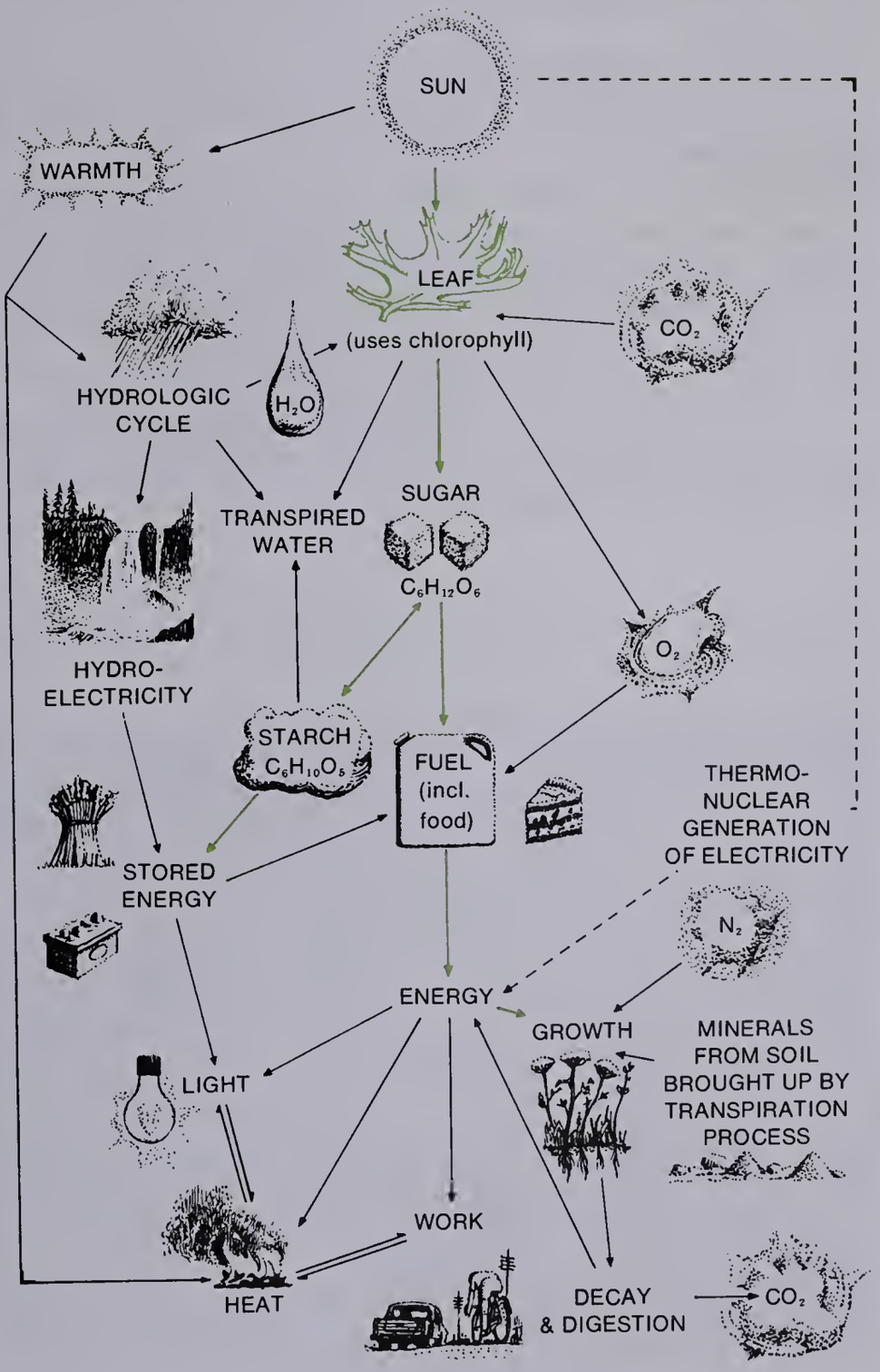
You may like to find out more about these.

1. (a) Slime-moulds can move about.
   (b) Barnacles, oysters and others do not move. How do they get their food? Find out about their larval stages (glochidia).
2. (a) Beetroot, mushroom, Indian pipe.
   (b) Female tanager, anole lizard, grasshopper.
3. (a) Fungi, dodder.
   (b) Volvox and some other primitive "animals." (See next chapter.)
4. (a) Some orchids imitate insects.
   (b) Branching coral, sea anemone, crinoids, walking-stick insect.
5. (a) No fungi have cellulose—some scientists do indeed put them and some other creatures in a separate kingdom, the Protista.
   (b) One or two very primitive animals make cellulose. (See Chapter 11.)

BUT IN MOST CASES WE HAVE NO TROUBLE KNOWING A PLANT WHEN WE SEE ONE.

Chapter 3

WHEREVER DO YOU GET ALL THAT ENERGY?



This is the most important chapter in the book.

Cows eat grass. Cats eat mice. Turkeys eat turkey pellets. All animals need food. All food comes from plants. If you do not at first believe this, that is good. Let us look at it more closely.

Cows are a simple example, but let us look at mice. They eat grain; but they also like cheese. From what is cheese made?

What about a kingbird eating a dragonfly? Dragonflies live the first part of their lives under water, catching other animals. What do these prey animals feed on? After emergence as a flying hunter, the dragonfly catches and eats other insects. Trace the "food chain" back again.

For more about food chains, see *Studying Insects*.

If you go far enough back, you will find an animal that eats plants. Work this out for a number of animals (you may not need 5 links for all of them).

Links	1	2	3	4	Final
Redtailed hawk					
Mink					
Mole					
You					

What does food do for your body? We sometimes say our bodies are like a factory. What part then does food play in this factory? List the jobs the power supply in a factory does. Now make a second list giving the jobs your power supply does in your body. Can you connect the two lists?

If you look carefully, you will find that your lists fall into two main sections—work and heat. Such jobs as making, repairing, moving and changing things all come under the

heading of work. When you play basketball you have fun. But you certainly work. You move your arms, you speed your body from one end of the court to the other, you throw the ball, you raise your body up off the ground as you score. You also get hot. And hungry.

A car engine has to have a cooling system. (So have you. How does it work?) When it is running it gets pretty hot. In doing this it uses up gasoline. Have you ever found out where gasoline comes from, when you trace it right back? Add it to your list.

Have you ever built a campfire? It's fun. It can work for you too. It can change things: melt margarine, boil water, cook hamburger, burn beans (if you're not careful!).

When water is turned to steam it can be used to push back the piston of an engine.

Early balloons used to carry a fire aboard. This fire heated the air which then rose with enough force to lift the people in the balloon.

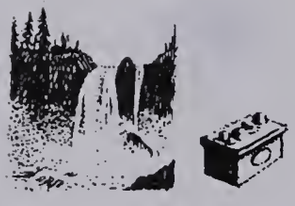
People say that you get warm twice from wood—once when you saw it, once when you burn it.

You might like to try making one of fireproof material like aluminum foil.

In cold weather your fire will keep you warm. Another way to keep warm is to jump up and down—or shiver. Both use food-fuel in your muscles. The fire saves your fuel by using its own.

What fuel does a campfire use? Where does it come from? Another item for your list.

Have you ever thought how the wieners and puffed wheat, honey and apples you eat become energy? They must be broken down into fuel units. Then they must be taken to your muscles or brain. How is this done? What happens to them there? What element is added to them to produce energy? Why do you breathe? It begins to look as though energy can be stored. Think about the fire, the car, an oil or coal furnace.



What about electricity? Some of it can be stored in batteries, true. But does it come from stored energy? Some electric generating stations burn fuel. Others use water power. What energy is stored in falling water that can be used up? Try to find out about the water cycle if you do not already know.

In five minutes write down all the ways you can think of in which energy is being used. Vast amounts are being used every day. How are they replaced? From plants? But how do the plants find the energy they store?

We have found that energy may be used either as work or as heat. These are really two forms of the same thing. Can you think of any source of warmth which is constantly flowing into the earth's system?

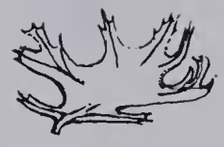
Take a thermometer into the sunlight. After a short while read the temperature. Now read the shade temperature. If you want to be warmed up you stand in the sun, but to be cool you find shade.

Let us take this experiment one stage further. Borrow a lightmeter, an instrument that measures the amount of light which can be used by a camera in taking pictures. Go into a woodlot in summertime. Compare the temperature and the light level there with those in the open.

Most people have made fire with a magnifying glass. It focuses the sun's light rays on one small place and concentrates the heat, causing a fire to start.

Find out about solar furnaces used for cooking in India and some other places. House designs can help us to keep cool in summer and warm in winter. How? Is this how a greenhouse functions? (See page 23.)

The sun's light and heat were caught by the canopy of leaves in the woodlot you were investigating. What did this do to the leaves, or for them? Take temperatures to see if they were being heated. What other work does a tree do that requires energy? It does not use muscles to dance around. Try this experiment:



Tie an ordinary plastic bag over the end of a leafy twig in the sun. After a few hours examine it. Can you explain what you see? Where does the water come from? How was it brought up to the bag? This is work; plants do a great deal of it, and it is very important indeed to them and to us. See Chapter 13.

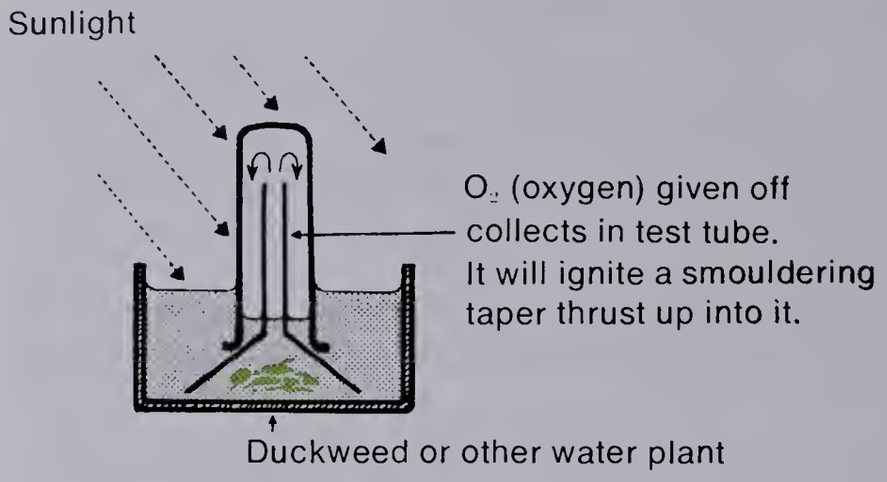
We are learning that light and heat are two forms of the same thing (energy). We know too that the sun is supplying the world with large amounts of this energy every day. We still need to find out how plants use it and store it for use by animals, including us.

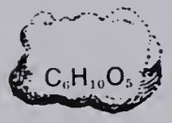
Cut the shapes of your initials in aluminum foil, in a size that you can fasten to a leaf. Leave them stuck there for a day or two. Now remove them, soak the leaf in ether or alcohol to remove the green colour. Heat the alcohol in a test tube by placing it in hot water. Soak the leaf in the hot water first. Then put iodine on the leaf surface. If it turns black it shows there is starch. Where is it? How did it get there? It must in some way have to do with sunlight.

Scientists have found that a plant, using the green substance in its leaves and other parts, is really a candy factory. We have agreed that a factory has to have a power supply, and that this must be the sun. Sugar is made by using the green machine and solar energy. What raw materials does this factory use? Here are some possibilities:

minerals from the soil
water
different gases in the air (nitrogen, oxygen, carbon dioxide)

Sugar is made of carbon, hydrogen and oxygen—$C_6H_{12}O_6$.


Sunlight
O_2 (oxygen) given off
collects in test tube.
It will ignite a smouldering
taper thrust up into it.
Duckweed or other water plant



Water is H_2O. Carbon dioxide is CO_2. If we add six parts of H_2O and six parts of CO_2, we find we have the right amounts for sugar. This is exactly what the plant does, though it is still something of a miracle to us, common as it is. You may have noticed that we had more oxygen than we needed—twelve units to be exact. *The plant gives these out as it works*. This is another reason why plants are so important to us. (See pages 123-24.)

With the help of your teacher you could set up an experiment. With heat added to dry white sugar (scorching it) you find that water and carbon dioxide are given off. But it was starch you found in the leaf. Starch and sugar are closely related carbohydrates.

Hold a small piece of white bread in your mouth for a few minutes, letting the saliva work on it. You notice a sweet taste. A chemical called an *enzyme* in your spittle has changed the starch to sugar. Here is the formula:

$C_6H_{10}O_5 + H_2O \rightarrow C_6H_{12}O_6$
starch + water → sugar

(NOTE: This takes place only with the help of an enzyme, as

the making of sugar from air and water needs chlorophyll.)

This can also go the other way. Sugar made in the leaves is changed into starch for storage, until it is needed for energy or to help build new substances the plant needs. It is stored in many places. We use cereal grains because they have food stored for the infant plant. We eat potatoes because the plant has stored food in its roots ready for next year's plants.

Maple trees send carbohydrates from their leaves down to the roots for the winter (to be stored as starch), but bring them up quickly in spring to make new leaves. You can dissolve sugar in lemonade, tea, milk and water. Starch will not dissolve. So maple sap in spring is sweet, and useful to us.

Sugar or starch can be made into other substances with the addition of more ingredients by the plant. Some examples are cellulose (see pages 72-3), cork, waxes, colouring matter, oils, resins, and wood. When you burn wood there is always something left. We call it ash. How did it become part of the plant? Where did it come from? Notice too that when you burn wood in a campfire you must have a good draught. A look at the chemical formula will show that to turn sugar into water and carbon dioxide again we must add oxygen.

But we do not need to make a fire to use these stored forms of energy. Our food gives us energy by the addition of oxygen to it in our bodies. The horsepower of a car engine does come from burning, however, using stored energy.

Even if we do not use the energy stored in plants, it is always returned in the end, after the plant dies. We call this rotting. It is a form of burning, and needs oxygen. It is done with the help of microscopic animals, which must have moisture. It does make heat; you must have heard of damp hay in a barn bursting into flame.

You could build a compost heap (see page 125), and test the inside temperature with a thermometer.

Malt is a kind of sugar. Find out how to make malt.

Chapter 4

THE GREEN WORLD

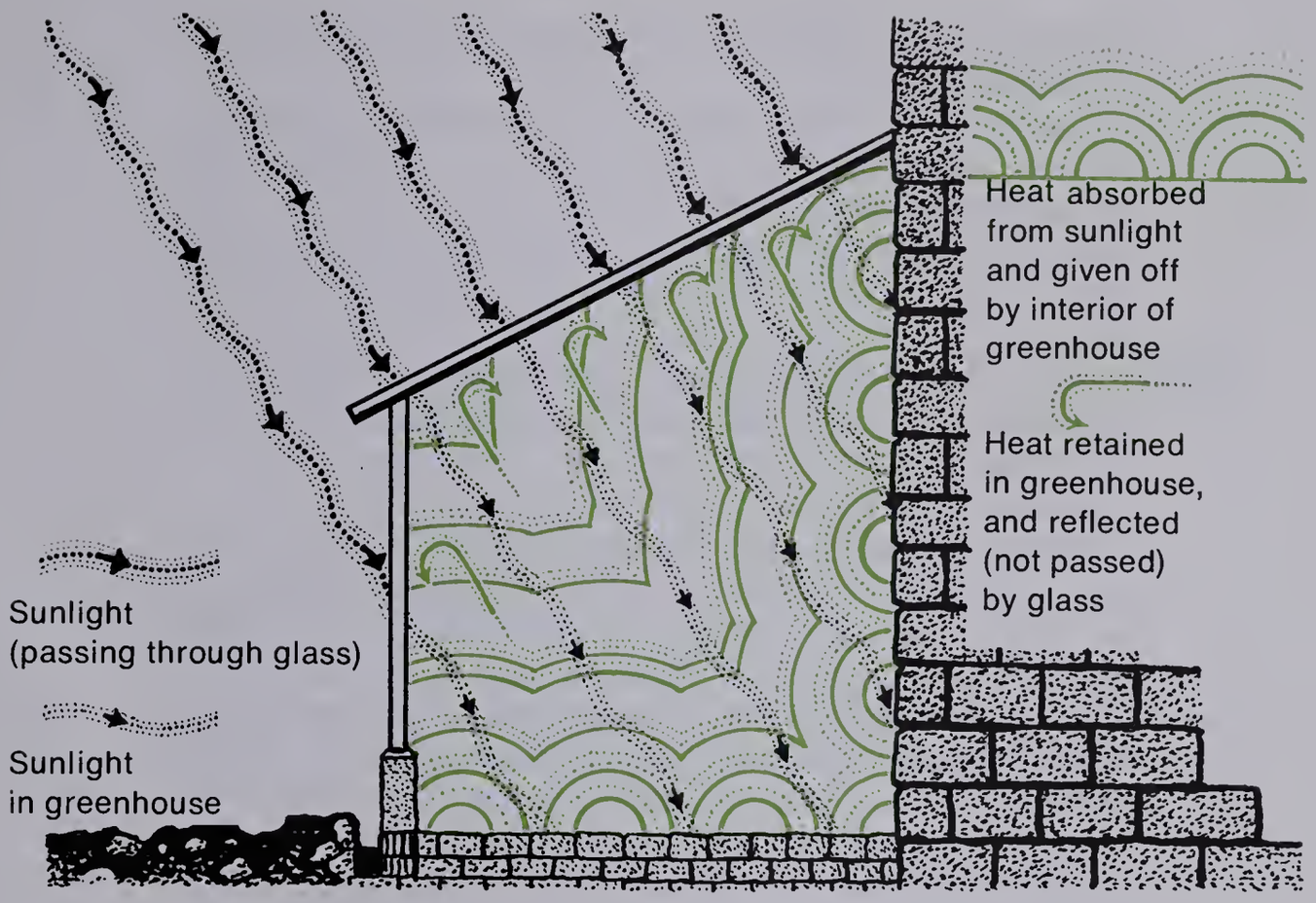
But *you* are not green unless you're a Martian in a science fiction story!

We have already found out that plants use sunlight; we have assumed that they use the green substance called chlorophyll as the secret ingredient which turns air and water to sugar. The chlorophyll does not become part of the sugar. It is more like a machine part or a magician's pot.

You have seen a rainbow and the varied colours in a raindrop, in the crystals on a sparkling snowbank, in the thin film of a soap bubble or in the film of oil on a puddle. Where do the colours come from? They are not the usual colours of snow or soapy water. Notice however that sometimes the sky is blue; and sometimes it is other colours like red, gold, even purple at dawn and sunset. Why?

The best way to find out is to use a prism. Your teacher will show you how to split a shaft of sunlight, or other light, into a rainbow-like band of colours. The colours are always

Double rainbow at Moosonee, Ontario.


Heat absorbed from sunlight and given off by interior of greenhouse
Heat retained in greenhouse, and reflected (not passed) by glass
Sunlight (passing through glass)
Sunlight in greenhouse

in the same order, and each has a wavelength, just as the stations on your radio or TV have one. We have discovered that light and heat are close relatives. If you go beyond the coloured part of the spectrum your prism has made, there are still rays. They are invisible but they have a wavelength too. Some of these are heat rays.

When light goes through the glass of a greenhouse, or of a room, it strikes the objects inside, including the invisible air, and is absorbed by them. These things then heat up, and start giving off rays of a different wavelength, that is, heat rays. These rays will not pass out so easily through glass, so the greenhouse or classroom gets hotter and hotter. You can experiment with this. How? What could you use?

The carbon dioxide in our atmosphere works in much the same way, holding the sun's warmth against the earth, and so making life possible.

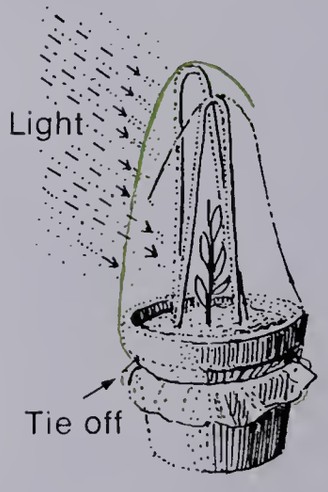
We should now find out which part of the light spectrum is used by plants.

If we shine light on a green leaf, only the green part of the light comes back to our eyes. How do you know? What happens to the other part?

Hold a thin green leaf up to the light. Which part of the light is coming through? What is happening to the other parts?

Set up an experiment. Grow some plants from seed in the styrofoam cups that are used for hot drinks. Lettuce or radish seeds would do nicely, or watermelon seeds or pumpkin seeds.

When they are a few cm high, make a double cellophane covering for each plant. Make sure it is lightproof, but arrange for ventilation. (See the sketch.) You should have several colours, but green must be one. Red, yellow, and blue would be good. Combine red and blue for "far red" light. You must also have a "control" plant covered with clear cellophane to prove that the cellophane itself is not what is affecting the plants. Also one plant should be covered with aluminum foil; it will be in complete darkness. Be very careful when watering the plants. Why should it be good to have more than one example of each part of the experiment?



Two loops of coat-hanger wire separate the cellophane for ventilation, but keep light out.

Wrap double cellophane carefully around the plant pot. Allow room for plants to grow.

You will have to leave your plants for two weeks. (But remember to water them.) Then examine them. Record your observations. Then try to explain them. Try to answer these questions:

(a) Which kind of light reached each of the plants?

(b) Why did some of them go pale? Why did some grow the way they did?

(c) Explain why few plants grow in the deep shade of a forest, especially in summer. What kind of light is mostly reaching the forest floor? Find an opening in the woods, perhaps made by the fall of an old tree. What plants do you see there, and why? In which season do most of our native wildflowers of the woods grow and bloom?

You can do a similar experiment by covering seeds with the coloured cellophane while they are germinating.

Why do trees have branches? Find the difference between trees that have grown in a forest and those which have grown in the open. You should by now be able to predict the answer.

Some plants have trunks, which are expensive to grow, in materials and time. In a forest, only the tallest can reach enough light to make good growth.

But in all places we find plants which operate "on the cheap." They take advantage of the hard work of others. What are some of these?

(a) Tropical forests have *epiphytes,* plants which live high up on the branches or trunks of trees. They do not harm the tree in any way. An example here is Spanish Moss (found in southern U.S.). How does the seed get there?

(b) Tropical forests also have many *lianas,* climbing plants. These do not need stiff, strong trunks, so they can grow faster. Some finally kill the tree and stand up in its place, being strong enough by then to do so. These are called strangler figs. We have many plants that climb: They use many different methods.

Different Ways of Climbing to the Light

(The plants are nightshade, wild cucumber, Virginia creeper, wild clematis. Which is which?)
Go to your library for answers.

(c) Find as many as you can and discover the method they use. Some examples which may be in your area are bedstraws, nightshade, Virginia creeper, Boston ivy, grape, poison ivy, wild clematis, pole beans, gourds of various kinds, bittersweet (celastrus).
(d) *Parasites.* One example is dodder. It has no green leaves. Why?

Dodder sucks sap from other plants, such as elderberry; its root withers away after it becomes established.

Now think about water as a place where plants grow. You may be lucky enough to enjoy skindiving. At least you must have seen colour photos by Jean-Jacques Cousteau and others. When you look through a thick layer of water what colour do you see? What parts of the light have been absorbed? It is like a summer forest. Does this mean that plants cannot grow deep down in water? It is thought that the earliest plants in the world grew in shallow seas around the coasts. But they became crowded and tried to spread out. Some eventually made their way on to the land. Others went to deeper water; and it is interesting

that these plants are coloured brown or red. They have *pigments* (coloured chemicals) which enable them to make use of the parts of light which other plants cannot use. For more about water plants see *Studying Streams* in this series.

Parasites do not have or need chlorophyll.

You may have thought of some other non-green plants:

(a) Of course, some lose their green leaves in winter. In our country many trees turn beautiful colours just before they drop their leaves. Scientists tell us that some of these colours were there all the time. They were masked by the green. Others were made during the breakdown of some of the useful materials locked up in the leaves. This is so that some of the materials can be saved. Part is turned into sugar and taken to the roots. The same thing applies to the chlorophyll itself.

(b) Some flowering plants feed on dead plant material with the help of bacteria or very small fungi. These are called *saprophytes.* One example is Indian pipe, which is a true flowering plant producing seeds but not needing chlorophyll to make food. It gets some of its food from microfungi working on other plants' roots.

(c) Fungi themselves are able to break down dead plant material—and in some cases live tissue—and so do not need chlorophyll.

Some scientists put fungi in a separate kingdom from either plants or animals because they do not have cellulose in their cell walls either; and a few kinds, called slime moulds, are able to move around to find suitable food! But we usually think of them as spore-bearing plants. (See pages 91-2.)

Chapter 5

IS A PLANT ALIVE?

One of those silly, simple questions that is so hard to answer is this: "How do you know you're alive?" There is no simple one-word answer. List the things which might help you to decide. It is harder than you thought. What rules for answering would you write? Would they work with clouds, an egg, a pine log, a rocket, a cherry pit, a fossil fern leaf?

One answer might be that something is alive if it can die. This does not seem at first to get us very far.

(a) A cloud sits on top of this peak all the time. The wind blows constantly too. How can this happen? Does the cloud defy the wind? Are the moisture droplets in the cloud always the same or do they change? Why?

(b) You have heard of "ghost towns." They have "died." This town has been there for hundreds of years. Have the same people lived there all the time? Children are born; old people die. People move in or out. What makes a town live?

The cloud and the town are both pictures of living things. How are you like them? What things are going into you every day; what things are leaving you? It is the balance between these things which keeps you alive or makes you die. You have seen pictures of starving children in

underdeveloped countries. You have seen a potted plant which someone forgot to water during a holiday.

Here are some experiments with plants. They show what happens when certain things are taken away from plants. (They are experiments in *deprivation.* What does this mean?) Some may not lead directly to death, but they may make the plants sick and this will show us what is needed.

Soak a packet of bean seeds in room-temperature water overnight. Next day plant one in each of a number of those disposable styrofoam coffee cups. How many should you prepare? That is your decision—read on. Make sure they are all planted in the same kind of soil and at the same depth. Keep them in a well-lighted window. Water them regularly, so that the soil stays moist, neither dry nor really soaking wet.

When the plants are a few cm high, experiment with various ways in which you think plants might die. Here are some suggestions:

1. Give no water.
2. Give one spoonful of water a day.
3. Give two spoonsful a day.
4. Keep the pot full of water all the time.
5. Keep the plant in a sealed space, so no air can get in or out.
6. Keep it in the refrigerator.
7. Keep it in the freezer.
8. Make a hole in a block of ice. Place the pot in this. Cover the ice with sawdust to prevent it from melting and from making the air around the plant's top cold. In other words, find out what happens when the roots are cold and the leaves warm.
9. Grow a plant in nothing but water—distilled if possible. Do not plant it in soil. You could use washed silica sand or vermiculite which have no food value for plants.

Make careful records of what you do and what you find out. Number the plant pots to make this easier.

Will your results be true? How can you be sure they do not just *seem* to be true? Scientists have certain rules. Check your answer against those which are dealt with in the next chapter.

Think-Tank

Whenever something stops interacting with its surroundings (environment), it is dead—and that includes your sense of wonder and discovery, and your imagination.

Chapter 6

SCIENTIFIC DOUGHNUTS

Suppose we want to know whether boys will eat more chocolate-coated doughnuts than honey-coated ones. The way we handle the finding out (research) is very important. The answers we get may be quite different with different methods. Only one will be correct. (Why doughnuts in a plant book? Partly because they may be fun as an illustration, since we all eat doughnuts. Partly because doughnuts are made from several kinds of plants. Which plants?)

1. Asking the right question

Our question is wrong. Imagine the answer, one way or the other. What further questions would you want to ask? Here are a few:

(a) How much more would they eat? Here are some figures:

i	Chocolate	32	Honey	31
ii	”	2	”	1
	(In both of these there is one more chocolate!)			
iii	”	32	”	16
iv	”	32	”	1
v	”	48	”	32

How could you compare these so that your answer was useful?

(b) Which boys are we talking about? Where did they live? How old were they? What, in fact, were the conditions of the experiment? The conditions will depend partly on why we want to know. The way the question stands, the boys could be Eskimo and Nova Scotian, rich and not-so-rich, two-year-olds and twenty-year-olds, all the boys in the world or just those in your classroom. It might be useful for an exporter of doughnuts (if there could be such a person) or of doughnut-making machines to know the answer for many different places; at least he would need to know how much one place was different from another.

But you might merely want to know how many of each to buy for the end-of-term party.

2. Sample Size

Look at the figures above. Both *iii* and *v* have 16 more chocolate. One has twice as many and the other, one and a half times as many. This might have something to do with the difference in total numbers. We can't tell. Look again at *i* and *ii*. Which is more reliable? The sample size is different in each case: 63, 3, 48, 33, 80. Which is the most reliable?

One boy, tested by himself, might choose a chocolate rather than a honey. Could we possibly decide from this that he would always choose chocolate? or that most boys prefer chocolate? The best way to be sure would be to test everyone. But this would take too much time and too much of our pocket money. We must decide somewhere in between. While the more the better, we have to be practical.

3. Random Sample

If we pick only boys we know, we might be tempted to pick those who we know will like the same things we like. To be fair we should include all kinds: hollow-leg ones, hamburger-shaped and weiner-shaped ones, picky ones and all the many other kinds. Because this is hard to do fairly, we try to find another way. We could write on pieces of paper the names of as many boys as we can of the right kind for our experiment; then draw a certain number out of a hat after mixing them up well. If our sample is big enough, we should then have all the kinds in the right ratio. Our results would be *valid*.

4. Variables

Your results could be altered by many things. Here are some. You can think of others.

time of day
how long since last eating
the amount of light, or fresh air
freshness of the food
amounts of each kind available
distance each boy had to reach for each kind

Conditions of testing must be the same all through the experiment and for everybody. Otherwise you could not be sure someone had not just finished eating three chocolate bars. This might make him pick honey today while usually he preferred chocolate-coated.

It is possible that one day the doughmaker forgot the sugar. You could not tell by looking. So someone (perhaps you) would have to test both kinds at each experiment. We should make sure that the maker did not change the coating recipe. Or that he did not by mistake give us cinnamon-coated—which happened to look just like the chocolate ones. Everything must be the same except the one thing we are testing.

5. Controls

At this point it might strike us that the colour of the plate could make a difference. All our experiments so far have been on white plates. If we test the next batch of boys using coloured plates we shall not know whether any differences were due to their being different boys or to the sickly yellow colour of the plates. So we should make sure we know which flavour they prefer on white plates; then next day try again with the coloured ones. Or we could try leaving one plate white one day and having the other coloured, and switching the next time. We could try purple, black, brown, green plates; but each time we must compare them with the white.

White is our control—the one we compare with.

Think back to our plant experiments on page 31. We must have a control, a set of plants which are not deprived of anything. If something should go wrong with them too, how would this help us?

Now consider your deprivation experiments in the light of what we have been discussing. Think about the proper sample size. If all your plants must have the same conditions, except for the test ones, your sample will be limited perhaps by how many plants you can pack on your classroom window sill. Would you use the same kind of plant all the time? Why? (Do you want to know the effect of these deprivations on just one kind of plant or many?) Will your samples be random?

Chapter 7

LIFE AND HEALTH

In trying to answer the big question "What are living things?" we talked in Chapter 5 about dying, because a living thing is something that can die.

We learned a good deal. But there are some other things that distinguish the living from the non-living. Sometimes we use the words animate and inanimate. You have heard of an anemometer? It measures wind speed. An anemone is a flower that moves in the wind. The old Greek word from which we get our words means wind; but it also means soul or spirit. Animated means spirited. Animism is a religion which believes that everything in nature (a mountain or a tree, as well as a bird or a bear) has a soul or guardian spirit. The Greeks thought that your soul was like a puff of wind imprisoned in you. When you died it escaped. You had to be careful when you sneezed—people still say "Bless you!"

Words are Like Living Plants

They grow; they send out branches; they give rise to new words; they change colour (meaning).

Take the word "nuthatch," the name of a bird which feeds upside down on the bark of trees. "Hatch" is the same as 'hack" (which is what you do with a hatchet, but not without asking for permission first). A bird "hatches" from an egg, using a special egg-tooth on its beak to "hack" its way through the shell. So a nuthatch hacks through nuts. Because it is small and weak, it gets above the wedged nut, throwing its whole weight behind each blow of its beak.

Our word "axe" comes from the French "hache" which means—? What are "hachures" on a map?

Today we do not find this a very useful way of telling one kind of thing from an other. How can we tell if it has a soul?

We have made our own rules. These are useful in many ways in science and now is a good time to look at them.

Here is how it works. There are two steps.

Step One. Make a list of statements which are true of *all* living things. Use the information we have already learned:

They breathe (respire), using oxygen.
They need food and water.
They grow. (See Chap. 11.)
They are found in all countries of the world.
They can reproduce. (See Chap. 15.)
They can repair damage.
They can react to some things outside themselves, for their good.
They come in all sizes, colours and shapes.
They change over a period of time.
They are made of molecules.

There are others.

Step Two. Some of these statements are true of non-living things as well. Put a check against those which are only true of living things.

To see how this works, try to write a definition of trees. What is true of all trees? What is only true of trees? Scientists do this sort of thing all the time. (See Chapter 8.)

Being alive is more than just not being dead. Remember what you were like when you had a really bad cold? Could you win a running race then? Would you go to a party when you had a stomach upset? Have you ever seen someone who has just become conscious after a serious operation? Such people are alive, but—. What happens to people when they take drugs or too much to drink?

Yes, there are degrees of aliveness. We call it health. It has to do with being able to carry out the things you need to do, as well as you can. When you experimented with the effects of water and light on plants (page 31), your plants did not always die. But some became pretty sick.

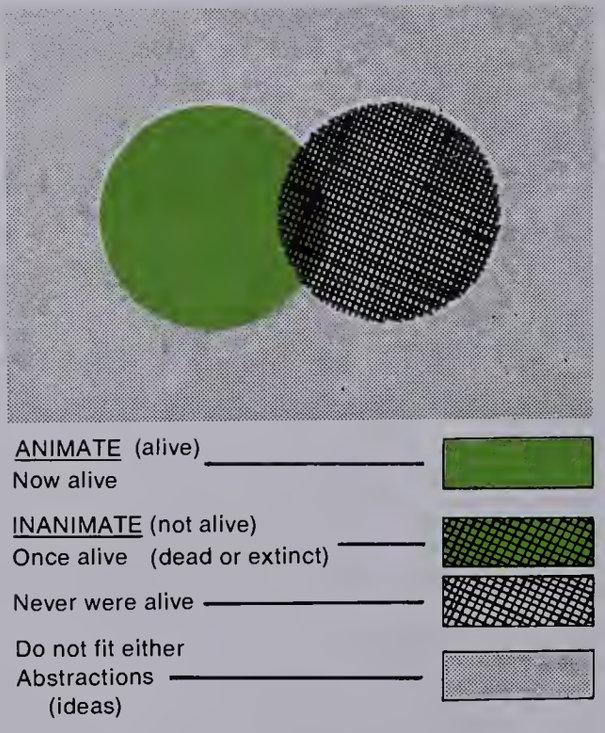
Below is a further experiment in deprivation. Its purpose is to find out what happens when certain food elements (chemicals) plants take from the soil are missing.

Check that all the proper methods we have discussed

are carried out. Defining your purpose is part of this. But we need to make it more definite. What elements are we interested in?

If you look at fertilizer bags, you can find the answers. There is always a formula. It might be K 10 N 15 P 5. This means that in every 30 parts (kilograms, grams, tons) there are 10 parts of K (potassium), 15 of N (nitrogen) and 5 of P (phosphorus). The K, N, and P in the fertilizer are in compounds. These must be soluble in water (as sugar is soluble in lemonade) so that the roots can drink them, and send them to other parts of the plant in the sap.

LIVING AND NON-LIVING THINGS



In which part of the diagram would you place—

1. Apples
2. Cider
3. Clouds
4. An egg
5. A pine log
6. A star
7. A rocket
8. A cherry pit
9. A forest
10. A fossil fern in limestone
11. Greenness
12. A salad
13. A Christmas tree
14. Hair
15. Beauty

MINERAL DEFICIENCY SYMPTOMS

This experiment requires great care but the results are worth it. A well-known plant scientist has worked out the details for you. Everything used here is easily bought; or you may be able to borrow some from a High School lab.

What you need:

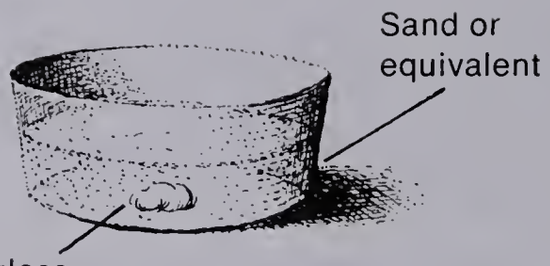
1. Eight plastic containers like those used for cottage cheese. Burn a small hole in the bottom for drainage.
2. Pure white sand, vermiculite, or perlite. These materials have no food value, even for plants.
3. 4.5 litres of distilled water. Why is this important?
4. Chemicals—

	Grams per 4.5 litres of water			
	Complete	Deficient in Nitrogen	Deficient in Phosphorus	Deficient in Potash
Potassium nitrate (KNO_3)	1		2	
Calcium nitrate ($CaNO_3$)	4		4	5.5
Potassium dihydrogen phosphate (KH_2PO_4)	1	1		
Magnesium sulphate ($MgSO_4.7H_2O$)	1	1	1	1
Ferric chloride ($FeCl_3$)	.5	.5	.5	.5
Sodium dihydrogen phosphate (NaH_2PO_4)				1
Potassium chloride (KCl)		2.5		
Calcium chloride ($CaCl_2$)		2		

Measure with care.

When you have made up the feeding solutions store them in the dark or in dark bottles. 4.5 litres is enough for 4 containers for 7 weeks. (Your experiment will take about 7 weeks, to show the symptoms properly.)

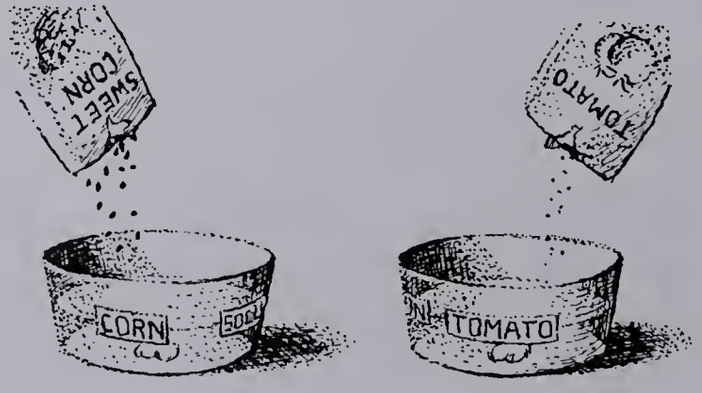
Procedure:



1. Tuft of glass wool covers drain hole

2. Wet sand completely with solution. Have two containers for each solution. Label them.

3. Plant sweet corn seeds in one container of each solution. (Follow instructions on package for planting depth.) Plant tomato seeds in the other container. Label clearly.



4. Keep warm. Keep well lighted.

5. Feed with 50 c^3 of solution on Mondays, Wednesdays and Fridays. Water on other days (and if possible on weekends). Sand should be moist but not wet at all times.
6. Record everything neatly and clearly.

Living Things Do Their Own Maintenance!

There is a saying that everything in the world is falling apart, unless steps are being taken to prevent this. Things rust, erode, rot, crumble, evaporate. . . . An interesting old word for death is "dissolution."

What steps do we take to maintain—

(a) vehicles?
(b) buildings?
(c) clothes?
(d) landscapes? (even rock will "decay"; people are trying to keep Niagara Falls where it is)
(e) other?

Living things can do this job for themselves. It is when they stop doing so that they are dead—and start to decay.

It is intriguing that parts of some living things may be "dead." Examples are hair and fingernails (fur and claws), the scab on a wound (though the wound is being repaired), the heartwood of a tree, the outer bark of a tree, deer antlers, and tooth enamel.

Chapter 8

WHAT DOES A PLANT LOOK LIKE?

How many different kinds of plants can you find in your school yard? Within 100 m of your home? A lawn will usually give you several kinds of plants, even if it is a well-kept one. Did you remember to look in shady corners, on tree bark, in cracks of pavement?

It is almost certain that you found more than you expected. They varied in size from a large tree to a small moss. They were of different sizes, shapes, even colours. If they were not, there would be no way of telling you had different kinds, of course.

Your class can divide into small groups, or you could do this by yourself.

Each group takes an imaginary trip to one of the following places. Using what you know, and adding what you can find in books, make a list of some of the kinds of plants you would notice at your destination. Do not worry about scientific names at this point. If you can find photos of each place, you could work from these.

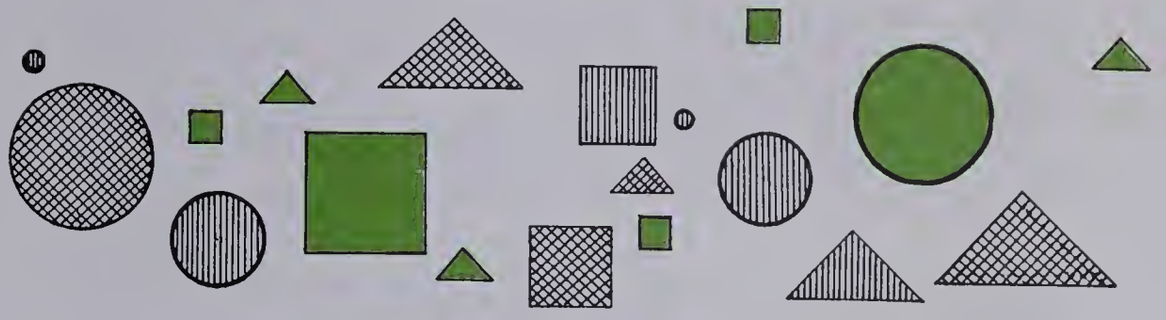
Examples of places to "visit" are:

an Ontario farm
sand dunes in Prince Edward Island
an arctic island
a country pond
a swamp
the Amazon jungle
a commercial greenhouse
a West Indies beach
the Queen Charlotte Islands
a city park in your area
the Arizona desert
the Rockies at Banff
a Lake Erie marsh
and many others

Share your lists.

However well you did your job, you wrote down only a few of all the possible plants. Think of how many kinds there must be in the world.

Look at This for Two Minutes:



It is almost impossible to look at it without forming groups or sets. How many ways could you arrange the shapes to *make sense* out of them? We do this automatically with everything we see, hear, or experience.

We use *differences* and *similarities*. How many of each are there above?

Now look at this:

You see the same number of shapes, and they are all the same as before, but it is very difficult to make a pattern in our mind. There are too many differences, arranged in too many different ways.

Think of how many ways plants can differ from each other. List some of these. Some plants may be like others in everything, except one, or maybe two, small ways.

We need a *key* to help us separate them. This is why we need names. We also need names for communication.

KEYS AND COMPUTERS

Apples, oranges, grapefruit, grapes, bananas, peaches—is there any foolproof way of helping someone strange to the country to identify these fruit?

The principle behind a key is to use the differences and similarities. So we could use:

shape	taste
colour	internal structure
texture of skin	seeds
texture of flesh	

Which of these are best?

Each step must be a clear choice between *two* possibilities. Would it be possible to give a choice between "large" and "small?" Why? Start with the easiest, most marked differences.

Here is one possible key for these six fruits:

1. A. Skin red, orange or yellow ..... go to 2
   B. Skin any other colour ..... GRAPE
2. A. Skin smooth ..... go to 3
   B. Not so
      (i) Skin fuzzy, thin ..... PEACH
      (ii) Skin thick, oily, crinkled
         (a) Colour orange ..... ORANGE
         (b) Colour yellow ..... GRAPEFRUIT
3. A. Roughly spherical shape ..... APPLE
   B. Long shape ..... BANANA

This is the sort of pattern all keys take. Each stage of decision must be so clear that anyone, including those quite unfamiliar with the objects, can find the right identification.

Could we construct a quite different key for those same fruits?

Construct a key to identify all the following: a hydro pole, a telephone pole, a flagpole, a pine tree, a cedar tree, a maple tree, a birch tree, a grapevine.

Construct another key for finding the names of all the people in your class.

Note

A computer works on exactly this principle—a switch is either on or off. "Programming" involves deciding what the choice is to be at each stage. Of course, because the operations are done by an electric current, they can go at extremely high speeds.

When data do not normally present a yes-no alternative, they must be modified to do so. So our normal way of counting by tens has to be changed to the *binary* method, where the choice is between a 1 and a 0. We count 0, 1, 10, 11, 100, 101, 110, 111, etc. instead of 0, 1, 2, 3, 4, 5, etc. All math operations can be done using this way of counting. How can a computer be programmed to multiply? divide?

EVERYONE KNOWS POISON IVY . . .?

"Describe poison ivy to me. Here is a good patch right in front of us. What about its leaves? It has three? But I can see several plants with fifteen or more. You've read this in a book, haven't you? Now look at the plant and tell me. Another way of putting it is that the leaves come in threes. Anything else you see? Well, what about the shape of the leaves? After all, other plants have leaves in three—strawberries, for one! It *is* hard to put into words, isn't it? Sort of round?

"Look at that tree, and that one, and these other plants. Their leaves are all 'sort of round,' so that doesn't help much. Yes, oval would be a good word, but perhaps it isn't enough. Are they pointed? How are they different from strawberry leaves? They aren't toothed on the edge, you mean? Right. What could you say about their outline? Yes, uneven—or jagged, perhaps. I always remember those scissors they give you in Grade One. A poison ivy leaf looks as if it had been badly cut out by a pair of these. This looks like a good field mark.

"Are they *really* shiny? Look at them again. No, they're

not, are they? This is another thing you read in books. I heard someone say the leaves were reddish just now; but are they? People sometimes copy in books what others have written without thinking or finding out for themselves.

"What would you say about their texture—rough? hairy? Yes, smooth might be a good word.

"Quite right, you notice that the leaves seem to hang down loosely. This is often what makes you notice poison ivy.

"What about the stem? Green doesn't help much does it? Someone has noticed that they are like a twig, woody. Try to imagine it after the leaves have fallen. It is poison then too, you know.

"Would there be anything else we might see in winter? Well, look at this patch for anything we might have missed up to now. Look at this plant. How do the flowers grow? After all, most of our woodland flowers are white, or whitish. Sure, they're in bunches, and they're small. What might come after them? Guess. Seeds, yes, but what do they look like? Berries? Yes, a dirty white colour. This is a giveaway in winter and spring. They are poisonous, but some animals, such as grouse, eat them quite happily and healthily.

"No, dogs don't suffer from it. But when they lie down in it like that, they can cause trouble for you. You can think how. Think, too, about how getting the poisonous oil on your boots can be dangerous."

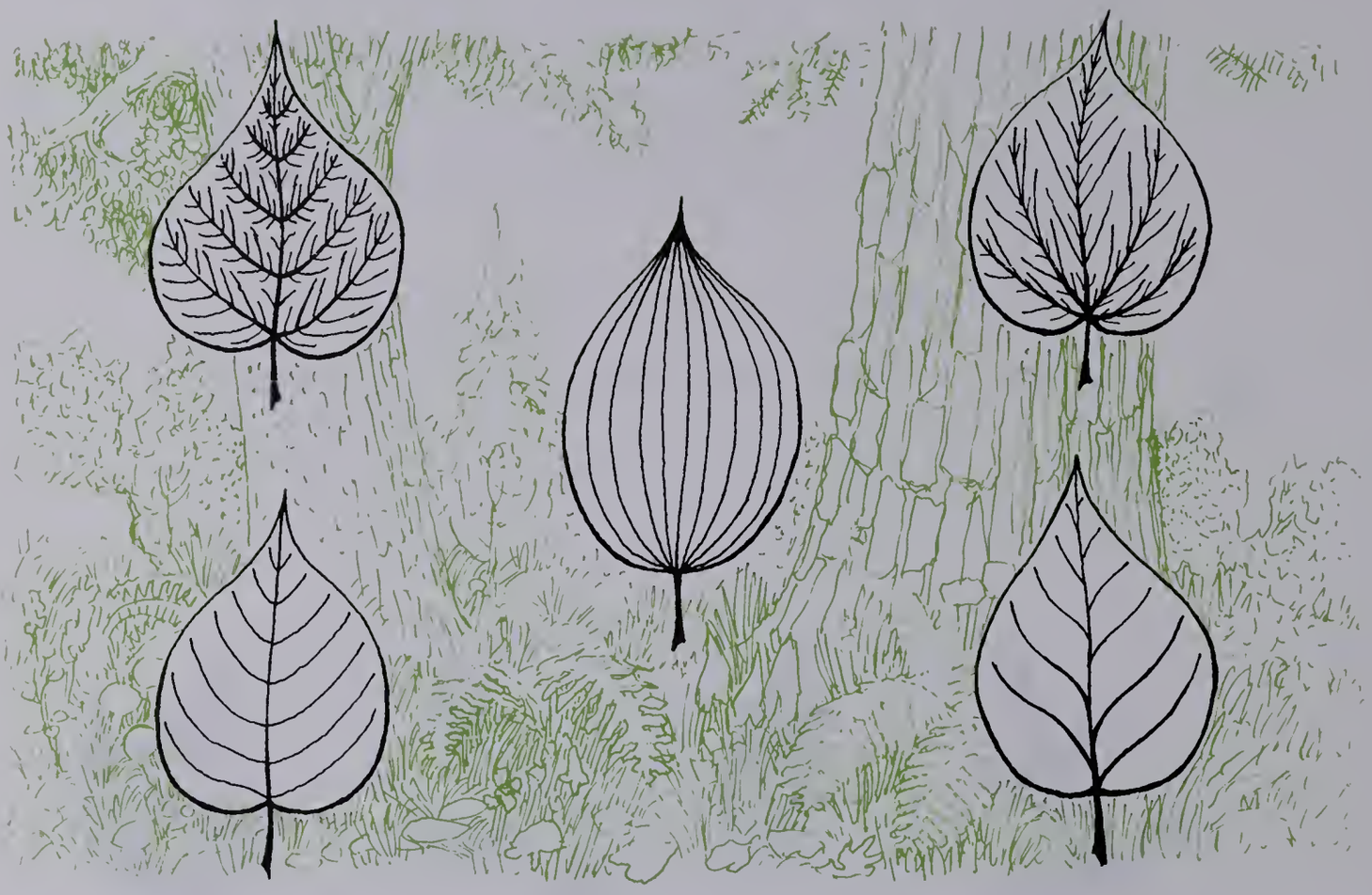
Try your hand now at describing a cedar tree, or something common around you. It is hard, even when you are looking right at it. We need to learn to look carefully, and to use the right words to describe what we observe. This takes practice. It also takes knowledge, because there are certain ways of looking at plants which are more helpful than others. The next few activities help you to learn something about these.

Leaf Classification

Arrange these in order from the simplest to the most complex:

Compare and discuss your answer with others.

Leaf Venation



There are many kinds of differences between plants. Learn to *see* them.

Arrangement of Flowers on Stem

Notice the ways flowers are arranged on a plant stem.

Collect as many different kinds of leaves as you can. Now try to find a way of telling them from each other. In what ways do they differ? Make a key, or try to arrange them from the very simple shapes through to the most complicated: a silver maple, a staghorn sumach or ash tree.

Apart from colour, how can you tell one flower from another? Examine some blossoms carefully. Use a hand lens or microscope (low power) if you can. Keep notes of

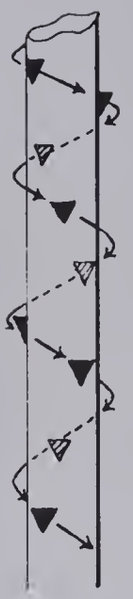
such things as number, shape, texture, length, colour of the various parts. Using wire and construction paper or plastic sheet, make enlarged models of some of your flowers. Show how they are constructed in whorls (circles of parts, such as circles of petals), one behind the other in a certain order. Do all your study plants have flowers? How do you explain this?

Making Maxi-Flower Models

1. Wind some green florists tape around a length of wire. Coat-hanger wire will do.
2. Cut a *whorl* of *sepals*.
   Look to see how many points you should have.
   These are usually green, but not always.
   Thread on your wire.
3. Cut out a whorl of *petals*. There may be more than one.
   Choose the correct colour or colours.
   Thread this too on your wire.
4. Find out how the *stamens* grow in your plant. How many are there? Cut a strip of material (perhaps yellow) into a fringe, with the correct number of stamens.
   Wrap this around the wire.
   Spread the stamens as they should be.
5. Examine the *pistil* of your plant. How long is it? Does it divide? Has it a knob on the tip?

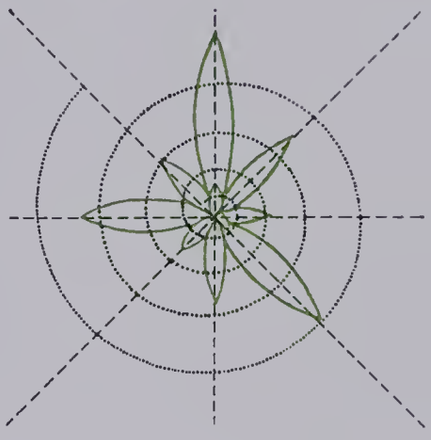
Make models of several kinds of flowers

Do a similar study with seeds. Trace if you can how the flower led to the fruit or seed. Identify the flower parts still present. An apple is a good example; use the whole apple, not just the brown seeds in the centre. Why do some plants cover their seeds with flesh, while others do not? (See page 100.)



Pick a stem of grass. Go down to the ground level. How are the leaves arranged on the stem? How many rows of leaves are there down the stem?

Pick a leafy stem of a common plant and look along it from one end to see the answer. Follow the leaf arrangement down the stem. How many times must you go round the stem before you reach one exactly below the one you started with? How many leaves do you pass on the way? You may find that you must go three times around the stem, and that the last leaf is the eighth after the beginning one. We can say this as a fraction—3/8.



There are only certain such fractions in nature. Which one was your grass? Yes, it was 1/2. But some wetland plants that at first look like grass are different. If you arrange all those you find in order, with least denominator first, you have a set which progresses logically. Can you spot what the next three would be: 1/2, 1/3, 2/5, 3/8? (The next is 5/13.)

Here are some plant diagrams:

Can you tell by looking at them—

which fraction formula they illustrate?
how far (what fraction of a circle) it is around the stem from one leaf to the next?
which are the youngest leaves?

Make diagrams for other fractions. Does the leaf arrangement seem to be related to the flower design?

Look at a pine cone carefully.

Try to find reasons for the leaf arrangements we have been discussing. Why might the leaves on a cattail have a different pattern from those on a vine, a dandelion, a maple tree?

Chapter 9

WHAT SHALL WE CALL IT?

You are invited to a party. You arrive in a strange recreation room full of people you have never seen before. Someone starts saying, "Sandy, I'd like you to meet Brenda—and this is Dick—Heather, Gail, Jo, Fred, Ann." You know you'll never sort them all out. But when you sit beside Marie (or is it Joanne?) you soon find that her horse's head pin means she's crazy about ponies, just like you. You'll remember her name now, because you know something about her that makes her real to you.

People are always picking flowers and asking, "What's this one called?" (and doing the same sort of thing with birds and insects). The worst thing about this is that once we have a name we often feel that ends the inquiry—we know the answer. But really we have gained very little—and we shall probably forget it by tomorrow, or this afternoon, anyway.

If our experience at the party tells us anything, perhaps we should try to find out something interesting about a plant before we bother about its name. That is what happened 'way back when plants were first given names.

If you are studying the plants of a hillside or some other area, there is no reason why you cannot make up your own names for them.

You could have a contest, voting for the most appropriate names for each plant. A plant with berries might be Redbead, or Gumdrop, or Dragon's Eyes or Fairy Cherries, etc.

1. Nicknames

What do you think interested early peoples about plants? Find some plant names which illustrate these things. Here are some examples: cow-wheat, Indian hemp, scurvy grass, baneberry, witch hazel, lady's bedstraw. Find others.

St. John's wort, a common plant, was hung up on the eve of the Feast of St. John to keep away evil spirits.

Jack-go-to-bed-at-noon.

Bedstraw close-up, showing minute hooks used in climbing.

Plants impressed people in different ways. Think about these old names: Gill-over-the-ground, Jack-go-to-bed-at-noon, baby's-breath, bleeding heart, welcome-home-husband-though-never-so-drunk. (Yes, it was a plant name!) There are others you can find. Why would a plant be called rattlesnake plantain?

Different places had different names for the same plant, and still do. A pine in Canada is not the same as one in Australia; potato is a different plant in Prince Edward Island and Alabama; there are many plants called Mayflower in North America. (Why should this be?)

2. Scientific Names

As soon as people started to look at living things because they were interesting they wanted to tell others about what they found. They wrote books. But the names they used had to be understood by all their readers.

At that time there were different languages as there are today. But educated men used one language they all understood. We still use it today in naming things. Do you know what it is, and why it was used?

Although a Latin name might be given, people found that there were differences among plants which in many ways were similar. There are trilliums in North American

woods. This is a scientific, Latin name. But there are white trilliums, and red ones; and if you look carefully you find nodding trilliums and sessile trilliums (look it up in your dictionary—what does it tell you?) and painted trilliums.

A common plant with a strong scent which attracts cats has the English name of catnip (though some call it catmint). A man called Linnaeus, who lived in Sweden about 200 years ago, named it *Nepeta*. But to be sure there were no misunderstandings he called it *Nepeta floribus interrupte spicatus pedunculatis* (which means "Nepeta with flowers in an interrupted spike, with all the flowers carried on the main flower stem."—phew!) Since this is more like a dictionary than a name, he gave each plant a Latin nickname, just for easy reference. Catnip he called *Nepeta cataria*. This is the name that stuck. Yes, there was another plant which he thought quite similar. He called it *Nepeta hederacea.* It now has a different name. Why?

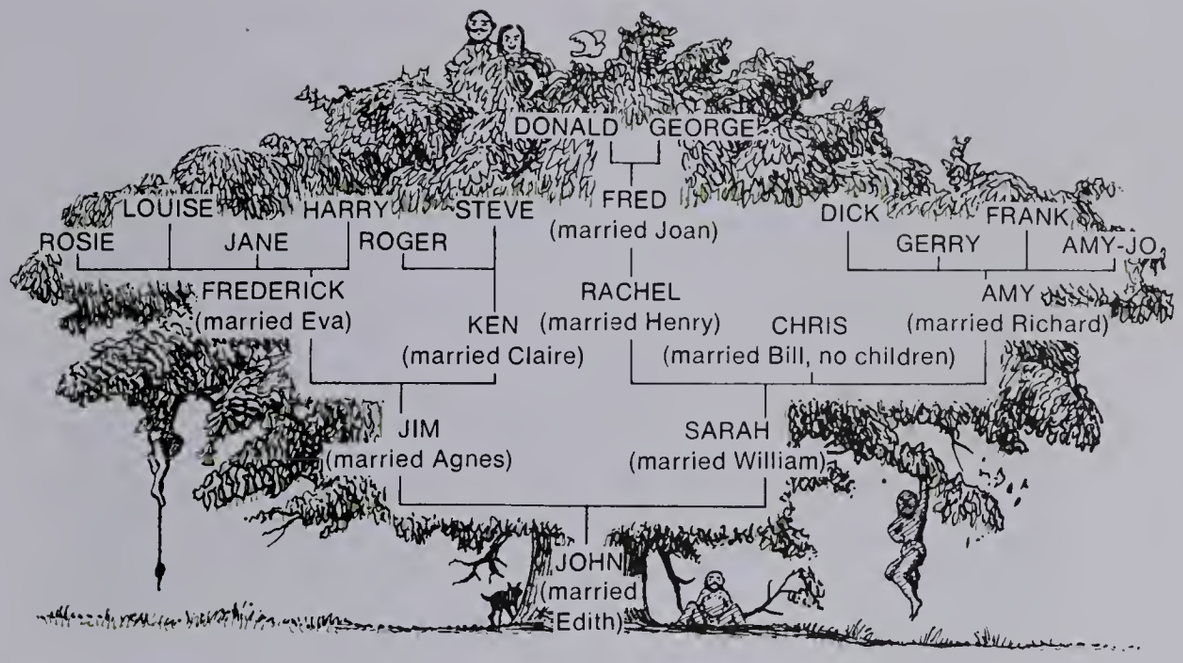
3. Classification

It is not by accident that catnip is sometimes called catmint. Pick some and smell it. If you look long enough, especially in wet places, you may find other plants with similar scents: garden mint, spearmint, water mint, peppermint. There are others: sage, marjoram, horehound, bergamot, thyme—look in your mother's kitchen cupboard. Though these are different in many ways, their flowers have roughly the same shape. They share a stem feature too. What is it?

It was convenient to put all these plants in one "bundle" in our thinking. We do this all the time when we have a large number of items to deal with or remember. (See page 43.)

An example of this is a "family tree." Try to get enough information to make one for your own family. Here is a simplified one to help you.

What relation is John to Donald; Sarah to Jim; Frank to Jane; George to Roger? As you can see, the further back you go, the closer the relationship. So we have put



all the specially scented plants we mentioned earlier into one big family. We sometimes call it the Mint Family, though its scientific name has to do with the shape of the flower. What does it tell us?

If we go far enough back in our family tree we find one man, who married a woman. Their children were a little different. So were their grandchildren. and so on. But there was a family resemblance.

The way we classify plants (and animals) tries to show this kind of relationship. It tries to show how, because children vary, new kinds (or species) can evolve, or descend from the same ancestors. Science detectives use all sorts of clues to help them in this.

What clues would help you to decide whether a daisy is more closely related to a dandelion or to a rose?

You need to remember that the more distantly related things are, the less likely they are to breed together. A dog and a cat never marry each other! A tiger and a lion can breed (in special conditions as in a zoo) but their children are sterile. We call them hybrids. There are hybrids specially produced by men for certain jobs; a cross between a horse and a donkey, for instance. But generally

only plants (or animals) of the same species can mate and produce offspring.

We shall look at ways in which some kinds of plants differ in a later chapter on plant structure.

Plant Signatures

At one time people believed some odd things (to us) because they did not yet know enough. Hundreds of years ago the idea grew that God had placed a sign or signature in each plant as a clue to its usefulness (or otherwise!). So when a plant had a leaf shaped like the human liver (which one has? see below) they claimed it was good for liver troubles. And they named it accordingly. An old name for the pansy is hearts-ease. There is a plant called eyebright. Can you see why these should be called by these names?

For another chapter on names and classifications see *Studying Insects.*

The Hepatica's name means liver-plant; its leaf is shaped like a human liver and is even spotted with liver colour.

LATIN IS EASY!

We have seen that the same scientific name is used for a plant all the time. It does not matter whether you are in Canada or Cambodia, whether the book you are reading was written a hundred years ago in England or last year by a Brazilian researcher.

We use names made up from Latin and Greek partly because this is how it all started, and partly because no nation is able to impose its language on the rest of the world. Some people are sensitive about that; but the people who used to speak Latin (who were they?) as their daily tongue are all dead and don't care. Everyone is now in the same boat, and has to learn a new language for science.

This may sound hard. But if you can learn English—and you have proved you can!—you can pick up this botanical language without much difficulty. As a matter of fact, *you already know some of it.*

Many plants that people found in the New World were quite different from those they already knew. Some were easy to name. The milkweed, dogbane, bloodroot are examples. The dogtooth violet is a name that backfired. Although at first glance it looks like a violet, a closer look tells us otherwise. What are the differences? Look at the

Canada violet.

shape and veining of the leaves, the structure of the buds, the number of petals, the shape of the seeds, etc.

In some cases the scientific names stuck. They were probably as easy to remember as any other.

Here are some examples of plants with well-known names which are the scientific ones based on Latin or Greek:

Trillium — How many wheels has a tricycle?
Hepatica — What is hepatitis?
Kalmia — Who was Peter Kalm?
Polygala — Is supposed to increase what? (The Milky Way is what we see of a galaxy.)
Geranium — Did you know we have wild ones?
Aster — Does it have something to do with astronaut?
Anemone — Means both wind and soul.

Here are other well-known garden flowers: salvia, forsythia, lobelia, clematis, iris. Find others and trace where the names came from. Do they mean something?

Names often have an interesting meaning. You remember that Peter means a rock, from the New Testament story. If your name is Linda, it may mean you are pretty. Latin names tell us something, and can be a great help once we catch on to the idea. The common daisy (day's eye, originally) is *Chrysanthemum leucanthemum*. You will recognize the first word. We buy Mum a bunch of "mums" on Mother's Day.

You must have seen that both words have the same ending. "Anthemum" means flower. The whole name means "white-flowered golden-flower", which is a better description than it sounds at first. In Latin the describing word, or adjective, comes after the name word, or noun.

Here are some more words to look for in scientific names:

dendro — means tree (what is a rhododendron?)
flor — means flower (in Latin; Anthemum is from Greek)
foli — means leaf (Latin)
phyll — means leaf (Greek)

carp — means fruit
rhizo — means root (Greek; the Latin word "radix" has been used with a small change for a vegetable)
hydro — means water (what does *"hydrophyllum"* mean? What is its English name?)

Colours:

lutea or flava or xantho (zantho) — yellow
chrys- means gold
alb- or leuco- means white
rubri- or erythro means red
nigra- means black

The second part of the name is always written with a small initial "canadense," "virginica," "americanum." But the first part always begins with a capital letter. So we have *Trillium grandiflorum.* We always use italics or underlining for Latin names.

A "sport" trillium.

Hepatica, a relative of the buttercup; the petals are really modified sepals; you can see what remains of the true petals.

A mud-dauber wasp on a small aster.

Bottom: Canada anemone, a relative of the Buttercup.

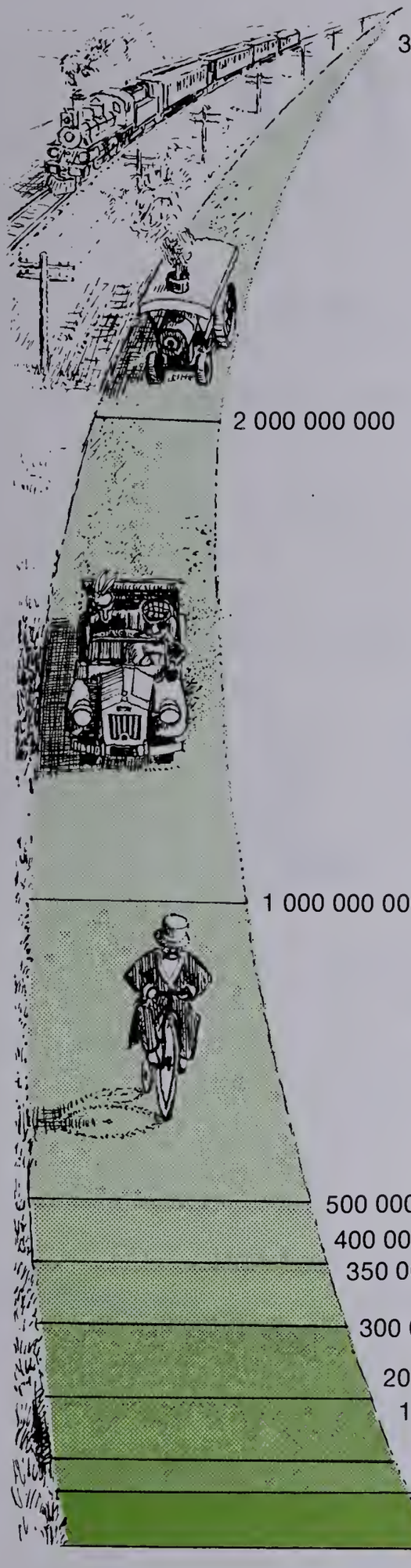
A parasitic wasp on Cranesbill (from the shape of its seeds).

Bottom: Bog laurel, a Kalmia or Sheep laurel.

Find out what the following parts of names mean and then discover plants whose names contain them:

WORD	MEANING	PLANT NAME
mollis		
fruticosa		
viride		
campanula		
mille		
heli		

(The old song about the Sally Gardens refers to the "Salix." What is it?)



3 200 000 000 Bacteria (most primitive plants)
3 100 000 000 Algae (earliest plants using photosynthesis)

THE PLANT JOURNEY

Great Great . . . Great Grandfather

—a million times removed.

2 000 000 000

All the pines in the world, and there are many kinds, came from one tree, the first pine that ever was.

If we go back beyond that, back —back—we come eventually to the first plant of all. What was it like? We do not know. What did it develop from? Again we cannot tell for sure. But there are what we call informed guesses. Scientists have looked at plants every way they can; new ways are being discovered all the time. One line of evidence comes from fossils.

1 000 000 000

We think we now have a good idea of the many stages of plant evolution, though there are blurred portions of the story even yet. But we can be pretty sure since enough examples still survive of all the main steps on the way.

500 000 000 Earliest land plants

400 000 000 Earliest vascular plants related to horsetails and ferns

350 000 000 Earliest liverwort (bryophyte), sexual spores

300 000 000 Coal measures laid down in great forests of horsetails, trees ferns, cycads, etc.

200 000 000 First gymnosperms (maybe earlier) Cycads abundant

150 000 000 Angiosperms (maybe earlier)

100 000 000 First true flowers (magnolia, maple, oak, palm, grape, buttercup, etc.)

65 000 000 Great variety of plants

Today New species still being produced

Chapter 10

MAKING A PLANT COLLECTION

There are many interesting projects:

(a) Collect wild relatives of tame plants. You will need a reference book which gives you plants according to families.

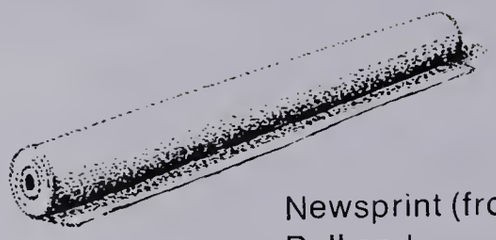
(b) Collect all the plants you can find of one family (the Mint Family would be a good one; or the Rose Family; or the Daisy Family).

(c) Collect plants which seem to belong especially to a certain kind of place—a swamp, a parking lot (yes!), a pasture field, etc.

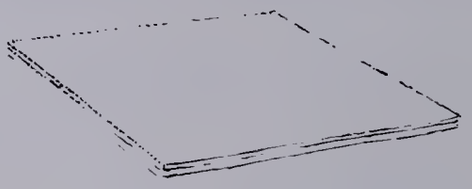
You can keep picked flowers for a while in water. But this is not very satisfactory for various reasons. Can you guess what they are?

A *dried plant collection* is the best way:

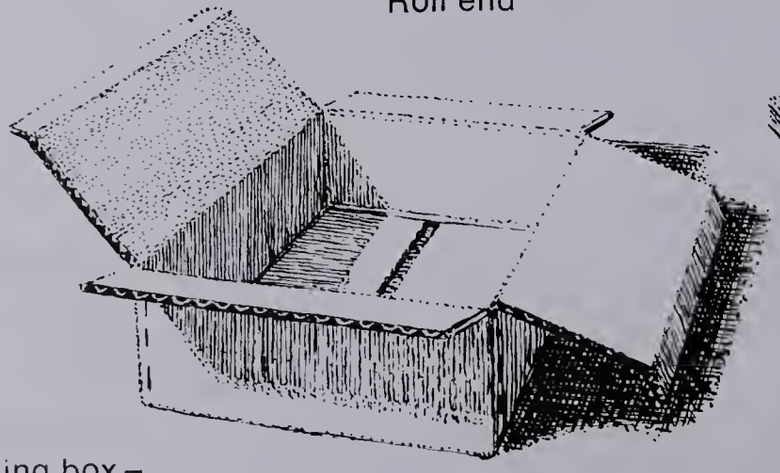
How Plants are Collected



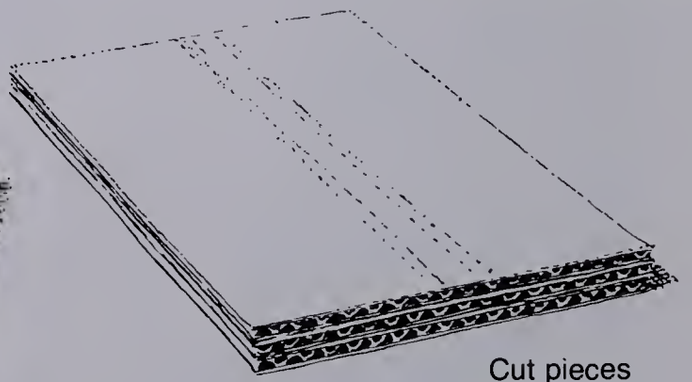
Newsprint (from newspaper office)
Roll end



Cut into
pieces 45 cm × 55 cm



Packing box –
(corrugated cardboard)



Cut pieces
50 cm × 60 cm

Collect the *whole plant,* including roots.

Make notes at time of collecting:

Where (place)
Habitat
Date
(Abundance, average height, etc., if wanted.)

Collecting bags –
Take a few plastic bags along on a trip.
Place plants in these to save from wilting and dying

Do Not Collect Rare Plants

Do not collect more than you need. (One complete collection per classroom should be enough. Each person can look after it in turn.)

To Dry Your Plant

Place between sheets of newspaper. These, folded in four, will be about the right size.

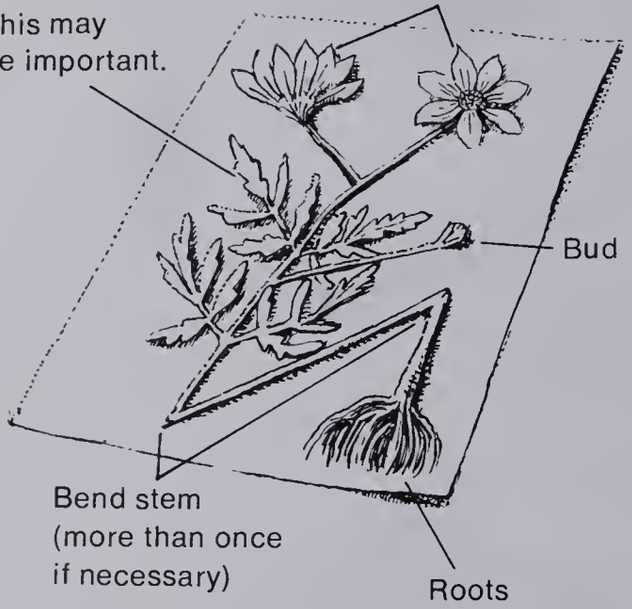
Put these between your corrugated cardboard pieces. A little weight to hold it down is needed. But not too much. If air cannot get in, then moisture cannot get out, and your specimen will rot, mould, or lose colour. (If working at home, an excellent method is to place it under a carpet where people walk.)

Since the dried plant will be stiff and rather brittle, you must arrange it carefully before drying.

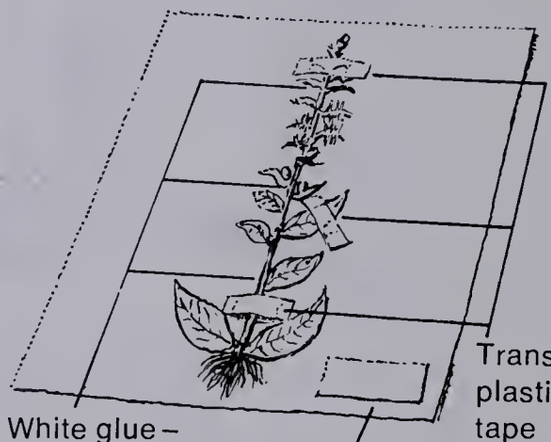
Arrange in a pleasing layout.

Leaves – Flatten both surfaces. This may be important.

Flower – May be front or side view (both if more than one bloom)



(If these are very thick, you may trim off the back side, which will be against the mounting paper.)


Transparent plastic tape (But this will cover your plant, will dry and discolour with age)
White glue – Apply to back of specimen, then carefully arrange on paper
Label – Glue in place

Common Name	INDIAN TOBACCO
Scientific Name	Lobelia inflata
Family	LOBELIACEAE
Collected by	John Robinson
Date	August 10, 1971
Place	Tallbridge, Ontario
Habitat	Damp Woods

To Mount Your Plant

Apply white glue to the back of your specimen, then carefully arrange on paper.
You can use transparent plastic tape (but it will cover your plant, and discolour with age).
Glue label in place.
File your sheets in a suitable order.
Keep an index.

For mosses and lichens you can let them dry out and store them in envelopes, filed in a small box. Do not crush them. If you want to examine them later, you can soak them in water and they will turn green and soft again, even after a long time dry. You can then see the details clearly under a microscope.

IDENTIFYING YOUR COLLECTION

There are various ways:

1. Thumb through picture books. Some of these books group plants according to colour of flowers. Peterson's *Field Guide to Wildflowers* is one, and is very useful. It also gives the families and their characteristics, so you can begin to learn these. Some are quite easy to know after a little while, and you can place even a completely unknown plant rather quickly.
2. Use a key. The information here is arranged in an artificial way but this is useful. Botanists often use details which you can see only under a strong lens or at certain times of year; they may even use something which the plant has lost over the years, but which they think it once had, in order to put it in a certain family!
3. Look at a complete botany book, where plants are arranged in their scientific order and where you can find an accurate description of the plant. But it may be in a "foreign" (scientific) language which you have to learn to understand; most books have explanations somewhere. Some even have illustrations!

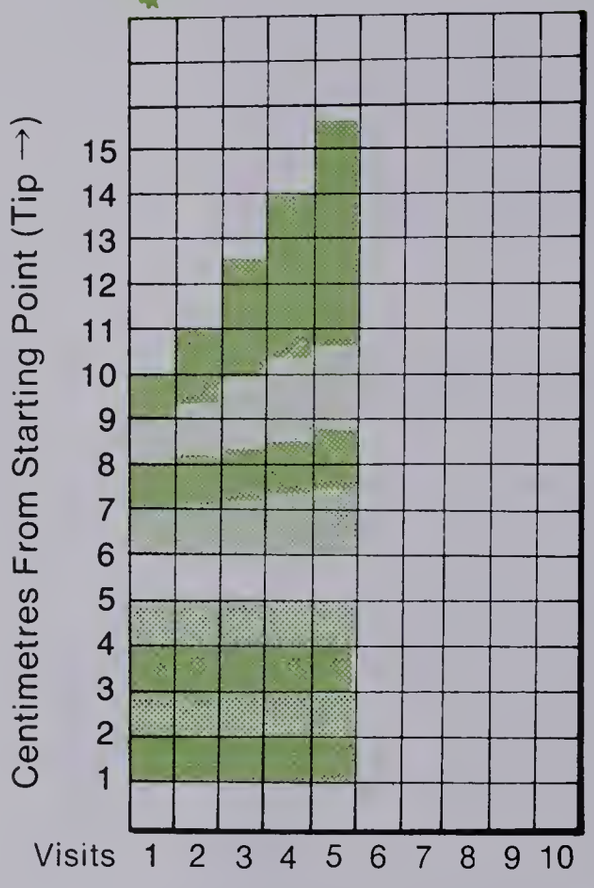
Chapter 11

GROWING UP

There are probably trees near your school, or your home.

Trees are growing year by year. Or are they? Have you noticed *how* they grow?

Growth of a Shoot



Where did most of the growth take place?

Take a growing plant. A bean will do; but any weed would be as good. Starting at an easily remembered place, 15 cm or so back from the tip of the plant, tie a ring of thread around it every cm. Make it tight enough not to move but not tight enough to cut into the plant. Any easily seen colour, such as red or white, will do. Prepare a graph, like this, leaving room for growth to be recorded.

Measure the shoot every Monday, Wednesday and Friday, recording the distances between threads and between the last ring and the tip. Record these on your graph. Where does growth take place?

Do the same experiment with the new shoot on a tree branch.

Measure the circumference of the main stem of a small tree, such as a Christmas tree, every 30 cm from the tip down. Graph your results. How long ago was the section 60 cm above ground level the leading shoot? How much has this stem increased in girth in that time?

If you can find a plantation of even-aged trees, say twenty years old, measure as many as you can all over the area. Measure the girth of the trunk at breast height. Now group your results, like this:

Circumference less than 30 cm	2
30-35 cm	4
35-40 cm	7
40-45 cm	15
45-50 cm	9
50-55 cm	3
etc.	

You will find the results give a specially shaped graph curve. Where do you find the smallest trees? Is there a pattern?

If you can locate a tree stump not too weathered (an elm killed by Dutch elm disease will be easy to find in many places), look at the "growth rings." Count them to see how old the tree was. Where did the new growth take place each year. Where was last year's new growth added? There can be only one answer.

Now think of this taking place all the way up the trunk and branches to the tips. Think of the layer grown five years ago. Where is it found? Where does it end? We have met another problem. If the growing layer is just under the bark, how did the tree find room for it?

A farmer staples his fence to a tree. What happens as the tree grows?

How does your mother act when you get too big for your clothes and start to split them? She either (1) puts

Bark of small bitternut hickory.

Birch bark should not be peeled off. The tree needs it until it is ready to shed.

in a strip of material; many trees do this; it accounts for the cracked pattern of the bark; or (2) she scraps them and buys new; some trees do this; you know one very well.

We have discovered two kinds of growth in plants:

1. The new growth at the end of the stems and branches. This is called primary growth.
2. The rings of new growth (concentric) added each year to the stem of a woody perennial. This is secondary growth.

But the question still remains as to how this is done.

(a) Peel off a piece of onion skin and examine it under a strong lens (100X), with the light shining through.

(b) Cut a growing cattail close to the ground. Peel off the outer layer. Now cut a thin slice across the stem. Take also a piece of one of the layers near the bottom. Examine these in the same way.

(c) Find a horsetail plant. Carefully cut a very thin slice of the stem and look at it under the microscope.

(d) Explore other plant tissues in the same way. A piece of fungus, a strand of algae, etc.

If you have difficulty cutting a slice of a soft material, run some melted wax around it, making a block. Then slice the block. Tape (with masking tape) bristol board over one edge of an old razor blade, and use this. BE CAREFUL.

In at least one of these experiments you should have been able to see some very small compartments with walls around them. These are cells. They are the building blocks of all living things and are therefore very important. We shall look at them more closely.

Chapter 12

CELEBRATING THE CELL

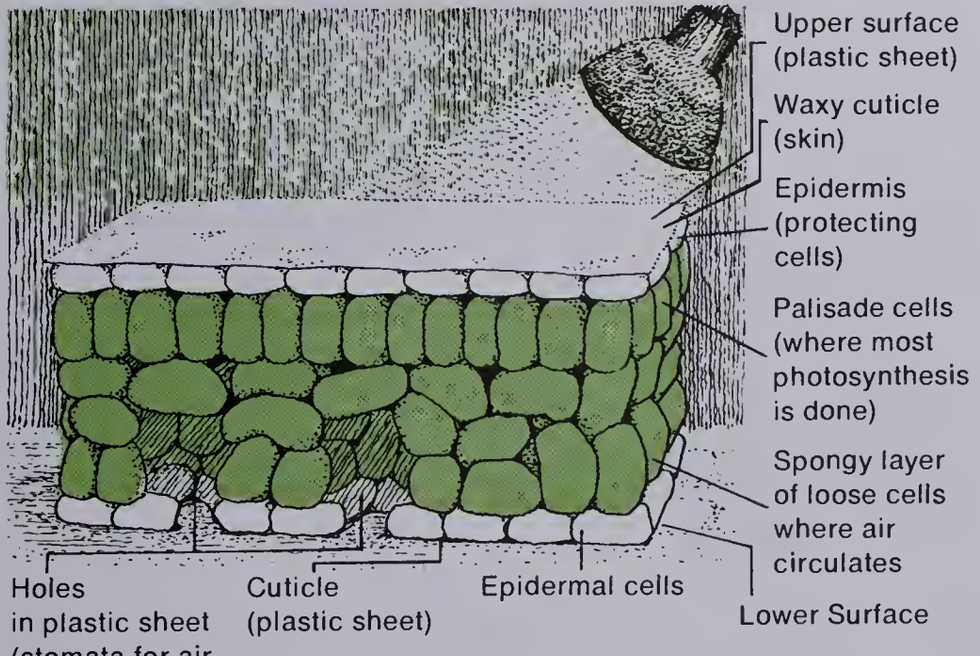
You have been able to glimpse plant cells. But what is a cell? The word was first used for a small room. Often this would be under a house and would be used for storing vegetables or wine. It might not have windows. You will think of a prison cell. This is quite a good picture of a plant cell in many ways.

1. IT IS ENCLOSED BY WALLS

A cell is rather like a plastic bag. Fill a plastic bag three-quarters full of water. It should be strong and not too large —one of those milk bags sold in the supermarkets would be fine. Squeeze the opening together in your hand to seal it. Turn it upside down and hold it loosely. It will sag and wobble. Now tighten your grip until the skin of the bag is tight against the water. It is now quite hard to change the shape of your "cell." It will stand up by itself and will support other objects, including other bags of water. What happens if you do not water a plant enough?

Making a model of a small section of a leaf in your classroom

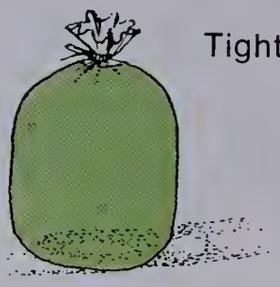
Shine a light down through, as if it was sunlight.


Upper surface (plastic sheet)
Waxy cuticle (skin)
Epidermis (protecting cells)
Palisade cells (where most photosynthesis is done)
Spongy layer of loose cells where air circulates
Lower Surface
Epidermal cells
Cuticle (plastic sheet)
Holes in plastic sheet (stomata for air to go in and out)

Making a leaf "cell" from a plastic bag

Heat sealing machines for this are now on the market at a reasonable price.

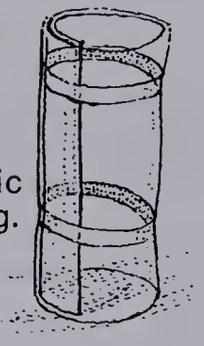
Not too full.



Tight!

Make sure it does not leak.

You can vary the shape by bindings of plastic tape before filling.



2. IT IS PART OF A LARGER BUILDING

Build a model of a plant leaf, using the drawing above as a guide.

Fill some of the bags with green water, using food colouring.

Twist garbage bag fasteners around the neck. Then run a band of plastic tape around to make it neater. Vary the shape of the bags by plastic tape bands before you fill. Cement (glue) bags together to stop slipping.

Another thing: take a sheet of paper; try to stand it upright on edge. How many ways to make it stand up can you discover? You can fold and roll it in different ways. Which is the strongest?

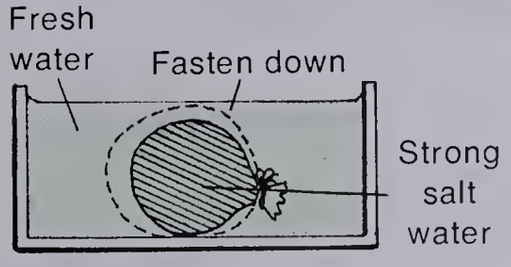
Most plant stems are cylinder-shaped. Roll up a piece of corrugated cardboard so that the channels run up and down the tube. Now you can see how plant stems are so strong, even when heavy with rain, or in a wind. Stick a number of such tubes together. More about these channel cells on page 72.

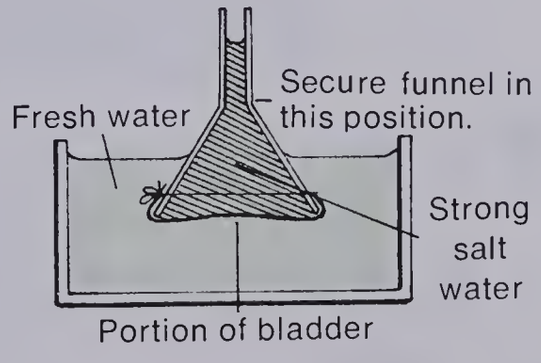
3. SOMETHING (OR SOMEONE) IS KEPT IN A CELL

Even a prisoner has some contact with the world outside his cell. His jailer brings him food, and orders. He is allowed to write to his family. His clothes are replaced with clean ones. His washing water goes down a drain. When his soap is all gone, he gets a new piece. Something is kept in a plant cell. It is called the nucleus. It is alive, so it needs food and water, and it excretes waste materials. It gives and receives messages, working with other cells in the same "building."

Now look at how messages and substances are passed in and out of cells. Your plastic bag would not lose water unless you let go of it. But if you inflate a balloon and leave it for a long time, it will shrink and go soft. Can you think how?

Obtain a fresh animal bladder from a road-killed animal or a slaughterhouse. Fill it with strong salt water. Tie securely. Measure the diameter. Fasten it down in some fresh water. Leave for a day or two. What do you find? Can you explain it? (If you cannot obtain a bladder, you can try a rubber balloon.) Is the explanation the same as for the shrinking of your air-filled balloon? Think of pressure. There is more pressure of air inside the balloon because it is more tightly packed than outside it. The water is more tightly packed in the bowl than in the bladder because the water in the bladder has salt in it, separating the molecules.





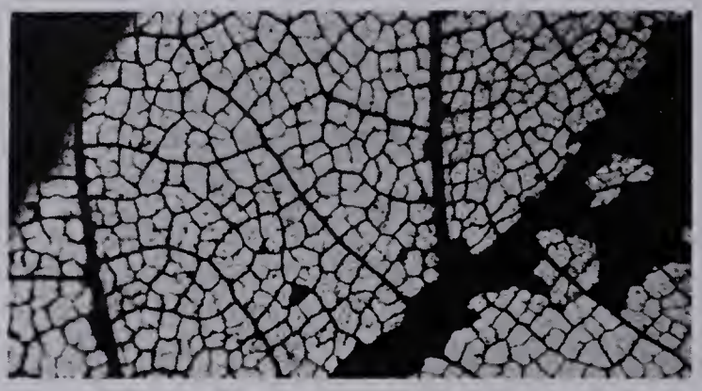
There is, you will say, some difference between the skin of your plastic "cell" and the skin of the bladder. Living membranes (another word for a thin skin) allow tiny amounts of some substances to pass through. Water and air are two examples. We call this process *osmosis*. What does this tell us about the cells in a plant? Cells are not filled with pure water. Can you now understand how they take up water? How do they lose it?

There are specially long tube-shaped cells in a plant stem—you have seen them already. These are placed end to end. If water evaporates from a cell at one end, what will take place along the chain of cells? If the other end is in contact with a supply of water, what will happen? This is not the only explanation for sap circulation in plants. See further on page 78.

4. A CELL HAS BARS AND STRONG WALLS

Plant cells, unlike animal cells, have walls reinforced with a sort of plastic webbing. It is called cellulose.

(a) You can sometimes find leaves which have lost their "flesh." We call them skeleton leaves. Most of what is left is cellulose. This is a very durable material.



(b) Make your own skeleton leaves by keeping a few in a box of moist soil. Keep the leaves damp. Watch what happens to them. Use a microscope.

(c) You can use chemicals to speed up the process. First crush the individual cells by gently beating the leaf.

Pepsin (easily bought) will dissolve the protein; it is what we use in our stomach for this purpose.

Saliva will change the starch into sugar and this will wash away in water.

Ether or alcohol will take out fats and oils and also the green chlorophyll.

Shine light through the leaf.

Look at it under a microscope.

Mount it in your notebook.

Cellulose can be digested by only a few animals. These include a primitive insect called a silverfish, often found in houses, and microscopic protozoa or bacteria. It is these in the digestive systems of cows, termites and cockroaches which enable such animals to use cellulose as food.

But other substances are used to strengthen cell walls. The veins you saw in the skeleton leaf contain *lignin*. Plant fibres, such as those found in natural (not plastic) rope, are mostly lignin. (Chewy fibres in celery are another example. Rotted milkweed stems give long fibres, used by North American Indians for making ropes.) It does not rot easily. Wood used in Egyptian tombs for coffins has lasted thousands of years. But dampness allows fungus cells to break down the lignin and feed on it.

Fungi, such as mushrooms, use *chitin* (ky-tin) in their cell walls. This is the substance which makes some insect bodies so hard—beetles for instance.

The outer skin of leaves and stems, which must be waterproof, contains wax. You can often find leaves in which insects have been eating the soft inside cells but have left the outside skin. (See *Studying Insects,* page 21.)

Cellulose is used by man. It gives bulk to food, and this helps in digestion, even though we cannot use the cellulose itself for energy.

In paper-making, the plant fibres (usually wood) are "digested" by chemicals which dissolve the brown lignin and leave the clean-looking cellulose.

Cellulose can be dissolved to form viscose. This is then made into fine threads of rayon.

Look in stores for things made of these materials—clothes and carpets are examples.

Cork is another plant material used by man. It is laid down in the walls of bark cells. It is waterproof. What else makes it good for bottle stoppers?

All these materials are made by the cell itself. The basic material, as we saw earlier, is sugar, made from ————?

But other substances are added by orders from the cell nucleus. Where do they come from? You can find some of them after plant material has been burned. We call it ash.

So the cell's work includes:

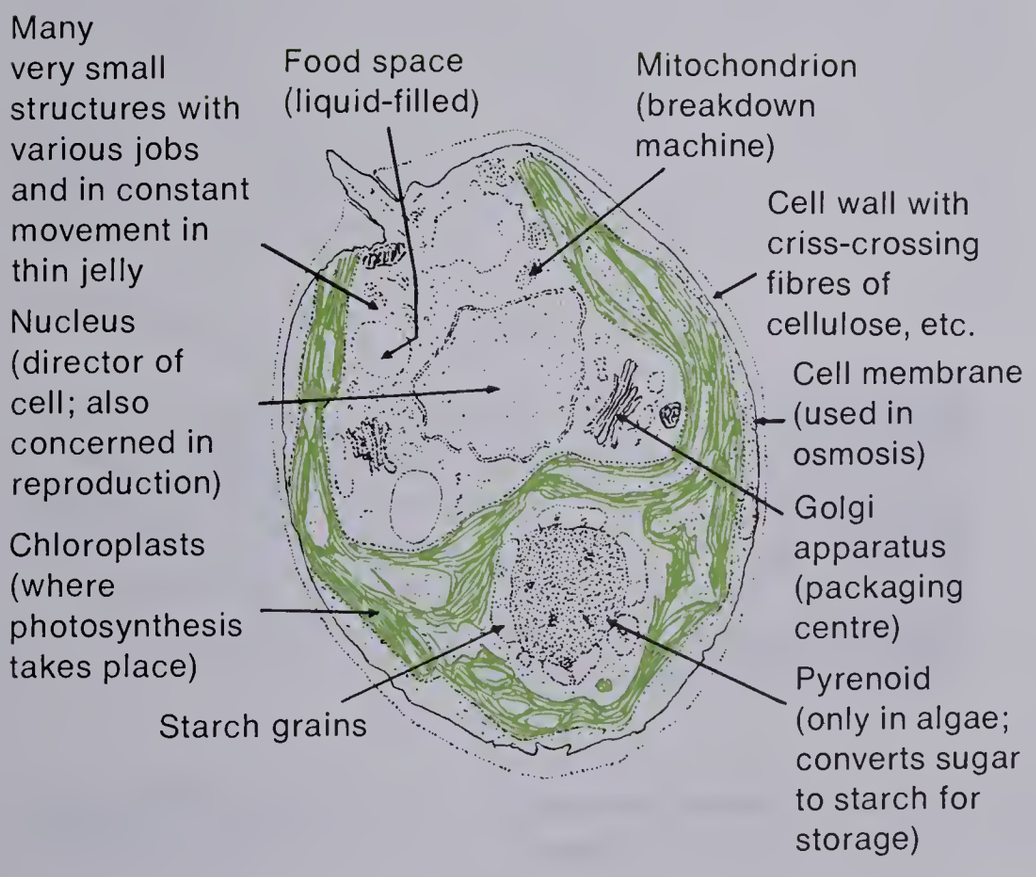
(a) Building the cell wall, including taking in the ingredients for different recipes, both from the soil and from the air.
(b) Feeding the cell for work and growth.
(c) Breathing—obtaining oxygen for combustion. (See Chapter 3.)
(d) Regulating the water pressure (turgidity) which gives cells their rigid strength.
(e) Disposing of garbage.
(f) Making chemical messengers which run from one cell to another telling what needs to be done. More about this later.
(g) Dividing cells. (See next chapter.)

Kinds of cells and ways they are arranged in the plant tell us about plant families and relationships. (See next chapter.)

The inside of a cell is far more complicated than we have so far discussed. We are still finding out about it. While this is far too big and complicated a subject for this book, here is a (simplified) sketch of the inside of an algal cell. With the electron microscope (which can magnify hundreds of thousands of times) scientists are now able to look at and photograph the very small details.

A pulp-mill in northern Quebec takes logs from the Saguenay River.

Simplified Diagram of a Cell of an Alga


Many very small structures with various jobs and in constant movement in thin jelly
Food space (liquid-filled)
Mitochondrion (breakdown machine)
Cell wall with criss-crossing fibres of cellulose, etc.
Nucleus (director of cell; also concerned in reproduction)
Cell membrane (used in osmosis)
Golgi apparatus (packaging centre)
Chloroplasts (where photosynthesis takes place)
Pyrenoid (only in algae; converts sugar to starch for storage)
Starch grains

Chapter 13

PLANT PLUMBING

If you look at the cells in a liverwort (*Marchantia* is common nearly everywhere in cool damp woods), you find there is no big difference between them. As we suggested on page 72, water passes from one cell to another by osmosis.

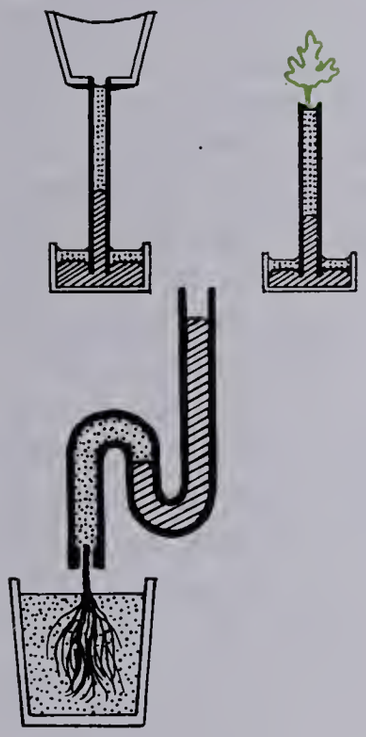
Some plants, those which developed later in history, have special tube cells set end to end and running from root to leaf. In the stem these are known as xylem cells. Once they become full grown, they lose the walls between them and become a long, very thin continuous tube. Another name for this is a vessel. You have blood vessels. The word vessel came from an older word, and this is used when such plants are called "vascular" plants.

You can drink lemonade with a straw. How? Why is your mouth like a pump? What pushes the lemonade up the tube? How great is the pressure? How long a tube could you use? (How high could you draw the liquid?) The answers to these questions, which you can find out in various ways, are important in understanding plant sap circulation. For instance, how does the water manage to get from the ground to the tip of a redwood tree 60 m high?

(1) Drawing-in creates a vacuum.
(3) Lemonade goes from high to low pressure areas.
(2) The atmosphere weighs over 6.3 kg per cm^2, and pushes on the surface of the lemonade.

Here are some experiments to help you find the answers —for there is more than one:

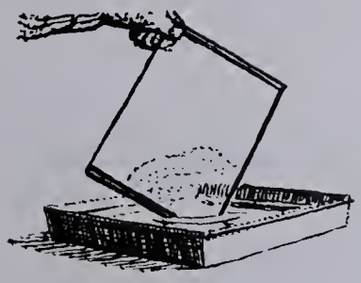
1. Coloured water is drawn into plant cutting with a white flower. (You can see the route of each sap tube in the petals.)
   Or use celery stems. Cut across to see vessels coloured.



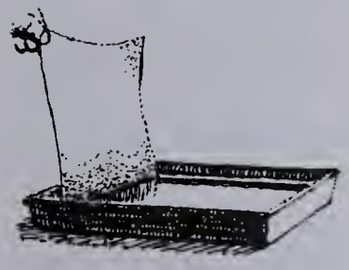
2. Set a porous clay pot (flower pot) on top of a tube filled with water. The end of the tube is in mercury.

   Cut plant sealed into water-filled tube.

3. Cut stump of plant sealed into tube. Mercury rises in tube, as water is pumped into tube by roots.



4. Hold two dry microscope glass slides together.
   Dip corner in water. Water spreads up into thin space between.



Blotting paper soaks up liquid. Why? Examine under lens.

Water will flow along narrow tubes or spaces. This is called *capillary action.*

One important condition is that the places where water is lost need to be controlled. One thing that goes with the development of a vessel system is a waterproof coat for leaves, stems, and other parts of the plant. Leaves especially need this because the carbon dioxide used in manufacturing sugar can be taken in by the leaf cells only when it is dissolved in water. For this reason, there are special openings (stomata) on the undersides of leaves. A tobacco leaf has 12 000 to a square centimetre. (About how many would an average leaf have?) The stomata allow air to pass into the leaf and moisture vapour to pass out.

If you leave a bottle of lemonade on a sunlit window sill for a time, what happens to the liquid? The hotter and drier the air, the more quickly the lemonade evaporates. So what do you do? Plants also cork up the openings! The special cells which guard them can close together when conditions start to get dry.

To test that a plant really does draw moisture from the soil, take two small pots with the same amount of identical soil. In one a plant is growing; the other has no plant. Pour same amount of water in each. Wrap each pot in aluminum foil. Twist the foil tightly together over the plantless pot. Wrap the foil around the lower part of the stem of the plant in the other pot, and fasten tightly. Now put each pot inside a large glass jar or a plastic bag and seal it off. After a few hours record what you see. Try to explain it.

We have seen that water rises in the vessels of a plant by:

1. Capillary attraction.
2. Osmosis—material in leaf cells is more concentrated through evaporation of water, so there is osmotic pressure of water from cell to cell upwards.
3. Loss of pressure in cells in the upper part of the plant—water is drawn in to fill the gap.
4. Root pressure—this too is osmosis, in root cells.
5. Capillary tension—the strength of a very slim column of water is far more than enough to allow it to be drawn up to the top of the highest tree. It may be as much as 100 times the pressure of the atmosphere!

Chapter 14

THE SHAPE OF GROWTH

You have grown beans from seed. Did you take the time and trouble to note carefully everything that happened as the seed germinated and the growing plant appeared and grew and branched? Could you tell someone exactly what happened?

What happens to the seed—does it just disappear? Does its position make a difference? In what direction does the root point? What about the growing tip? What were the first leaves like? When did they appear? Were the next leaves like them? How soon does the first flower bud form? Where?

Grow some beans in a jar. Roll some paper towels or newsprint in a roll, soak it and stuff it into the jar. Place some soaked beans between it and the glass sides of the jar. Keep the base of the paper in water.

After the seeds have germinated, carefully take three of the seedlings:

(a) Turn one upside down, so that the root is pointing upwards, and replace in the jar.

(b) Make one shoot grow through a glass tube held horizontally.

(c) Grow another similarly through a tube which has been darkened so that light will not pass through.

What happens to the growing tips of all these plants? What forces are at work?

Grow potted plants in a sunny window but without any room lights. Leave one in the same position. Turn others around a half or quarter circle every few days. What happens? You have already grown seedlings in the dark. (See Chapter 4.)

Find wild vines, or grow morning glory plants from seed. Observe carefully what happens when the tip of a tendril comes in contact with an object such as a twig. Keep your observations going for two days or more.

In each of these experiments something is affecting the

way the plant grows. Did you identify gravity, light, touch? Something which makes a plant change direction is called a tropism. How does this connect with the tropics? (Look it up.)

Tropisms may be positive or negative. You had both in the first project above. We find geotropism, phototropism, chemotropism, etc. Can you identify these? So although plants cannot walk from place to place they can move.

Grow seeds of many different kinds of plants. Or make careful notes of plants growing in gardens, greenhouses, nurseries, or farms. How are they different from each other? Before you look, make a list of ways in which you think they might differ. You may have to change this as you go on.

We have already, in previous chapters, talked about some of these differences: leaves, flowers, and so on. But one of the big differences is in plant shape.

Find poems about trees. There are many: about the birch, the oak, the weeping willow, the elm, the pine. Better still, make your own word pictures of these, either as poems or otherwise. Illustrate them in some way if you like. Find music which seems to fit the personality of the tree. Some examples might be the song "Down by the Sally Gardens" (we mentioned this earlier), "The Pines of Rome" by Respighi, perhaps "Cherry Ripe" and "Birch Canoe." What makes each kind of tree so different from any other? You can often tell them apart from quite a distance, even in winter.

Tulip-tree canopy.

Fit these names to the tree shapes:

ELM, CEDAR OF LEBANON, MAPLE, NORWAY SPRUCE, SPREADING JUNIPER, WEEPING WILLOW, PALM, FIR, (make others of your own).

These shapes, or those you think of for yourself, make good starting point for patterns or collage pictures; ice, coathanger-wire, or paper sculptures; driftwood, or styrofoam carvings; wall plaques made from seeds; and so on.

If we look at the different ways in which the flowers are arranged on different plants (look back at pages 48-9), we discover a whole new set of plant shapes. Think of grape, wild carrot, milkweed, wheat, for a start. What is the secret behind these shapes; what produces them?

Compare the winter twigs of these trees. Group them in *two* sets: Ash, Maple, Butternut, Oak, Sumach, Poplar, Apple. Did you decide to use the way the buds grew out of the stem? How does this determine the peculiar shape of a tree or other plant? Look!

In an evergreen plantation you can often find trees which have had their main, or leading, shoot damaged by accident or attack by insect or diseases. What happens in these cases? How do you pick them out?

Why do we clip a hedge? It is partly because of height. But clipping (or pruning) has other effects. Discover how Christmas trees are pruned, and why.

You can often find plants in the woods which have been nipped by animals. If this happened some time ago, or even several times, we may find quite a bushy shrub with a mass of branching side-shoots. This may be quite unlike the usual shape of the plant.

Pruning

(a) Dormant (sleeping) winter twig.

(b) Growth of same twig in spring. Side buds produce leaves. End buds lengthen the stem.

(c) End bud has been pruned, either by man or perhaps a deer.
Side bud nearest the cut end takes over the job of producing the lead shoot.

(d) Sometimes clipping the twig end makes two or more side buds produce shoots.

Why do we nip back "Mums"?

Scientists have discovered that the end bud produces a chemical called a *hormone* which prevents the side bud from extending into shoots. When the bud is destroyed, the nearest buds start to grow out; they in turn prevent the others from doing so.

These chemicals are called *auxins.* They do many jobs. Here are some experiments to show how they work. Since they are very powerful in their effects on plants, very small amounts are used—as little as 1/10th of a part per million parts of water.

This is how you obtain this sort of dilution. One gram of substance in 1 kilogram will give you 1 in 1 000. (1 kilogram of water = 1 litre). Take one part of this solution and mix with 10 parts of water. How many parts per million do you now have?

This is your starting point. You can repeat the process so your new solution is 1/10 as strong; and go on doing this until you have 1/10 of a part per million. You now have 5 different strengths for your experiment, from 1 000 parts to 1/10 part per million.

You may have to borrow an accurate balance, say from a high school laboratory, in order to carry out these experiments properly. Your teacher will help you. Do not make any more than you have to. Chemicals to use can be bought

from chemical supply houses. Suggested are: giberellic acid 10% as a sodium or potassium salt; indole-acetic acid, also as a salt; you can use also 2-4D, which is a commercial weedkiller—look on the can or bottle to see how concentrated it is. BE CAREFUL. It is a poison. Do not get it on your skin.

The experiments in the earlier part of the chapter are all carried out in the plant by auxins or other hormones under the influence of gravity, light, pressure, etc.

Place some green tomatoes in a box with one or two really ripe apples. Compare their rate of ripening (turning red) with others in a box without apples. (For controls see Chapter 6.)

Carefully transplant some young deciduous trees into pots, or obtain some rooted cuttings of coleus either from a nurseryman or by rooting them yourself. (See experiment with "rooting compound" below.)

Cover all plants with plastic bags. Do not expose to strong sunlight. In some bags place ripe apples. Watch for the effects, if any. (Ripe apples produce a growth substance called *ethylene* which gives off fumes into the air.)

Coleus plants (which are the familiar red-foliaged plants used in planters and gardens) have leaves in pairs. Snip off the *blade* of one of the leaves in a young pair. Keep careful watch for a week. If you are interested in going further, duplicate this experiment, but this time cut off the end bud. You can also cut off all but a small (say ⅛) part of the blade of one leaf in a pair. Try to figure out where the chemical messengers are being made and what they are saying.

Obtain some "rooting compound" from a hardware store, drugstore or garden shop. Experiment with various plant cuttings, using the substance in various concentrations. Always use "control" plants. Use more than one plant in an experiment, if you can, to avoid chance results. Keep accurate records and measurements. Remember to give your plants good conditions—especially water them regularly.

Obtain some 2-4D weedkiller. (CAREFUL. Read the directions.) Experiment with various kinds of plants. You can either grow these yourself, obtain them from another source; or use weeds. Make sure you have broad-leaved plants (such as dandelion, bean, pigweed, tomato) and narrow-leaved plants (such as grass, corn, onion, daylily, cattail). Spray the 2-4D on the leaves, using different concentrations, as described earlier. You will need controls, too, so you will need to set up quite a complicated experiment. But the results will be interesting; make sure you record these; then try to explain them. Make a project booklet with facts, tables and graphs of results, pictures and your guesses at the reasons (hypotheses).

Grow twenty watercress seeds in each of several covered plastic pans or Petri dishes. Sprinkle the seeds on a square of wet blotting paper. Grow for one day in the dark (but watch what happens carefully, especially in the first hour—you can peek from time to time) and then for one day in light. The water you use should contain a different strength of giberellic acid for each dish, as described earlier. Label your dishes and note the results. Measure the length of the roots and of the shoots. Use average figures for each dishful.

Do a similar experiment, using lettuce seeds. The seedlings should be in the dark for a day and under strong summer-long light (fluorescent is fine) for two days. Measure the root lengths.

Grow a number of *dwarf* peas to the 3–4 leaf stage. Put a few drops of giberellin, of various concentrations, on the leaves of each. Record plant heights.

Soak some wheat grains in water for 6 hours, then plant shallowly in vermiculite in a large dish. Cover with a plastic bag to prevent drying out. Water enough to keep the "soil" moist. Plants will germinate in 5-6 days. Allow to grow until shoots are 5-8 cm long, but before leaves begin to open up. With a razor blade (carefully) cut off the tip of each (about 0.5 cm); then cut off a piece of shoot one centimetre long. Place these in test tubes with different

strengths of indole-acetic acid or 2-4D, as before. Measure the change in length overnight. Graph your results.

New ways to use these remarkable growth substances (as they are often called) are being found all the time. They have been used to set fruit, prevent early fruit drop, ripen fruits earlier or all at once (for easy harvesting), kill weeds, defoliate forests, prevent stored potatoes from sprouting and force cucumber plants to produce more female flowers (and so more fruit).

Some other actions growers take are interesting too.

Obtain a batch of tulip bulbs (say 6). Divide them into 2 groups. Plant one half in a plant pot which is kept indoors in warm temperatures. Allow the other pot to stand outside in freezing temperatures for 6-8 weeks or place in a refrigerator. Then bring it indoors. Compare the flowering success of each.

You can do the same with dandelion rosettes. Carefully dig them up and plant them in fall. Allow one half to stand outside in the cold for a few weeks, and the other half to stay warm all the time. Keep them in short winter-length light until the cold plants have been brought in. Then increase the length of "day" to about 12 hours. Compare the flowering success of each group.

The previous project suggested that number of hours of daylight per day has something to do with flowering. Ask a nurseryman in your area how he produces chrysanthemums all year, or poinsettias exactly at Christmas. The effects of cold and day length on plant hormones may be the important factor in the above experiment. Let's see.

Effect of Growth Hormone on Stem

Mix a tiny amount of each of these hormones with some lanolin—your druggist will let you have a small amount of this. Stick a blob of each of the mixtures on *one* side of a growing shoot, such as a bean, making sure that the plant

is lighted from above. (See page 79, Chapter 14.) Observe and record what happens. You can place a piece of bristol board beside each plant, and record the change in curve of the stem at intervals, say every hour.

While we are discussing the shape of plants, we must remember some other important factors:

1. The amount of moisture and other soil substances available will affect the way a plant grows. Sometimes the same plant growing in very dry and very wet conditions seems hardly the same species. A tree growing in an exposed place where strong dry winds blow will often be one-sided and stunted. The cells on the windward side cannot grow as well as the protected ones, so leaves and branches are found more on the lee side. We are tempted to think that the tree was blown sideways and so it grew that way.
2. The most important thing of all is inheritance. Sometimes they say that the best way to keep healthy is to choose healthy parents! Jesus remarked that people do not gather figs from thistles, or grapes from thorn bushes. A daisy seed will never produce a plum tree. Perhaps you understand a little now why this is so. The next chapter will go further into the matter of seeds and all that.

A large elm growing in a virgin forest in Ontario.

The Pattern Tells A Story

1914
When the tree was 6 years old something pushed against it making it lean. The rings are now wider on the lower side as the tree builds "reaction wood" to help support it.

1924
The tree is growing straight again. But its neighbours are growing too, and their crowns and root systems take much of the water and sunshine the tree needs.

1927
The surrounding trees are harvested. The larger trees are removed and there is once again ample nourishment and sunlight. The tree can now grow rapidly again.

1930
A fire sweeps through the forest. Fortunately the tree is only scarred, and year by year more and more of the scar is covered over by newly formed wood.

1942
These narrow rings may have been caused by a prolonged dry spell. One or two dry summers would not have dried the ground enough to slow the tree's growth this much.

1957
Another series of narrow rings may have been caused by an insect like the larva of the sawfly. It eats the leaves and leafbuds of many kinds of coniferous trees.

Chapter 15

MULTIPLICATION

Unlike the green bottles hanging on the wall, which became less and less until there was none, plants seem to increase in number, especially weeds. (See page 129.)

1. VEGETATIVE REPRODUCTION (SPLITTING)

Collect some algae from a pond surface. Keep them in warm pond water. Examine them under a microscope. Look especially at the cells. These plants may cover the whole surface of a pond with a thick blanket during a summer, provided there is enough light and food. How does this happen?

If you break these algae apart, does it kill them? What happens? These are the simplest, most primitive plants we know (except for bacteria, which are perhaps not really plants at all, but are thought to be the organisms from which plants developed, hundreds of millions of years ago.) They multiply by dividing. Is this an interesting math idea? This is the same thing that happens to you every day, even when you are asleep. This is how you grow and your body mends wounds. Some simple plants and animals which are only one cell big do not stay together after they have split in two. But there are some plants found in water which stay together even though each cell is a separate living thing. Most ponds will produce example of Volvox. (Look in a *Studying Streams* book.) They are like a football crowd or a regiment. They keep together and act as one. But if they are separated they will go on living and will even come back together again.

If you are clever, you have been wondering how algae are found in ponds which dry up sometime during the year. Some plants are able to produce cells wrapped in a waterproof coat. They can stand even years of dryness without dying, but start to grow and multiply when water comes again. They are called spores.

But there are other kinds of spores, used in multiplying (reproduction).

A Mouldy Trick

Spores are floating around in the air all the time. They have been found miles high in the atmosphere. Can we demonstrate this?

What are the conditions which will make it possible for them to grow successfully? Think of some which might be involved:

dampness or dryness?
light or darkness?
presence of soil? other kinds of "dirt"?
warmth or coolness?
plenty of air or lack of it?
age, colour of the object it grows on, acidity, smoothness?

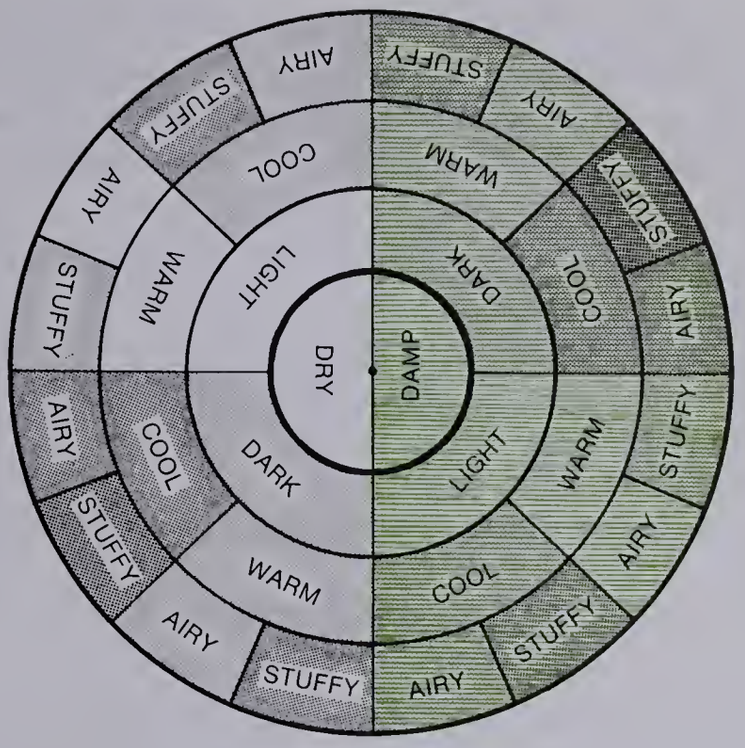
Think of mould on old bread. You have seen this. Try to remember what you have noticed about the conditions under which it grew. Pick out those which seem most likely to be right. (It may seem to you that bread goes mouldy most quickly when it is left in its wrapper in the darkness of the rerigerator. This is a good start.) You may decide to look into the influence of:

moisture	temperature
light	air circulation

You have now constructed a theory which says that these four things in some way affect the growth of fungus spores (mould) on bread. Your next job is to test your theory, or hypothesis. Remember that you will need:

1. enough pieces of bread,
2. controlled conditions so that only one factor at a time changes,
3. accurate records.

How many different ways can you arrange the four variables?



Yes, 16. Can you now predict how many there would be for 6? 10? If you are not sure, work it out with your own diagram. You will have to decide how long you are going to wait for any results—before you start looking elsewhere. What will be the best way to keep results? Will it be enough to write a check mark or a cross against each? Do you want to record the amount of mould that grows in a certain time? Why? What will this tell you? How could you record this?

2. SPORE PLANTS (PTERIDOPHYTES)

Make a Terrarium

Your teacher will help you. Instructions may be found in *Studying Streams*.

When ready to plant, spread some charcoal over the bottom to absorb bad odours. Then put in some sand. It would be good to shape this in an interesting way. You may like to introduce a rock or two or small log.

Collect some examples of moss and lichens—as great a

variety as you can find. Some other small plants may be taken too, but if they grow too large they will spoil the effect, so be wary. Often other plants will come up unexpectedly anyway. How? Arrange your collection in the terrarium.

Remember:

Where you found the plants; was the situation wet or dry? on a rock, a log or the soil?
Do not overdo things; the plants will grow. In any case a mishmash of little bits is not as effective as a well-arranged display of a few kinds. Experiment for the best effect.
Try for variety and contrast.
Make sure all the plants are pressed down in contact with the sand.
Thoroughly dampen the whole display.

Try to identify the plants.

Watch for mould. Very likely spores will be in the material you brought in, or in the air even. This can ruin your show. If signs appear (and you will find that the terrarium becomes very humid especially if it is placed in the sun), prop up the glass cover for a while. The terrarium will need very little watering. Water given off will collect on the lid and drop back—a miniature world!

Very probably you will find that some of your mosses produce short stems with what look like buds on the tip. Examine these carefully. Eventually (in dry weather) they will open up and let out some very fine powder. The cone-like heads of horsetails and the gills of mushrooms give rise to similar spores.

Moss and fern spores are somewhat different. You may not discover easily their life histories. Out of the many millions produced that float around invisibly in the air for a long time, only one or two may drop on suitable, damp ground. It will then start to grow into a little plant, which will not be the same as the one that produced it.

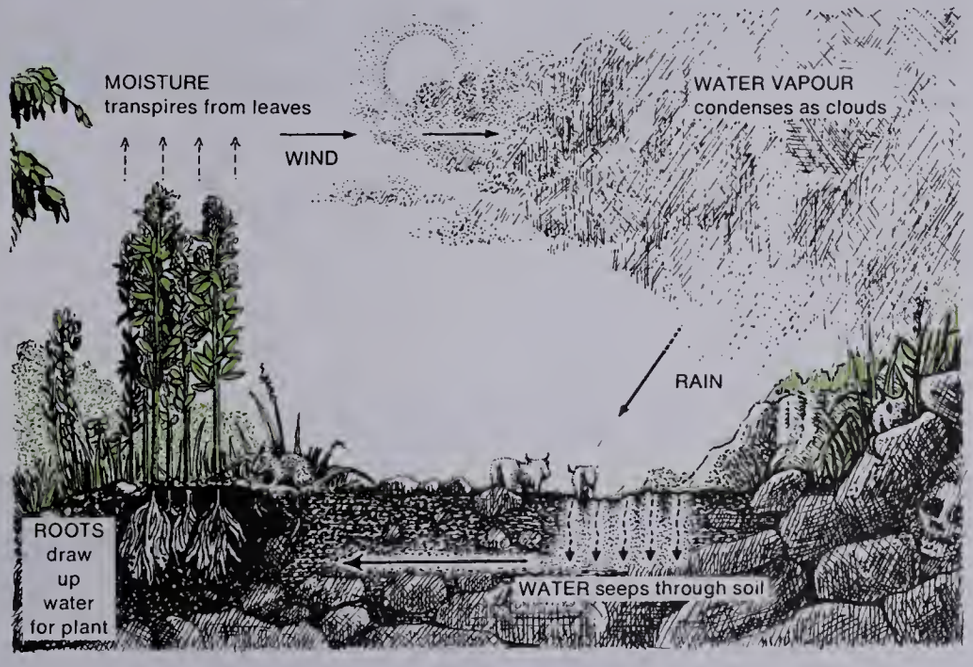
The new plant, a baby fern (sometimes called a *prothallus*), gives rise to two kinds of cells, one female and the other male. The male sperm has a tiny hair-like oar. When a thin film of water is present it swims across to a female

(egg) cell and joins it to make one new cell. This is called sexual reproduction or fertilization. It is the start of a new plant which will go on to produce more spores. One generation produces the fern with spores; the next generation produces the plant with sex organs. A moss's life story is much the same except that in this species male and female cells are produced on separate plants.

Though these plants are rather primitive, simple and early to appear in the history of plant evolution, they are important.

The Water Cycle

(Powered by sun energy and gravity)



Making a Spore Print

At certain times of year, or under certain conditions (what?) toadstools and mushrooms of many kinds are easy to find. These is no real difference between these two terms, though sometimes they are used to describe those you must not eat and those you can.

If you gather some of these, you find they give off their spores in three main ways:

(a) The *puffballs* produce great clouds of spores like smoke when you press them (if they are ripe).

(b) The *spore fungi* have thousands of tiny holes inside

Ostrich ferns.

Some fungi have gills which shed their spores.

Fungi, living on the ground or inside logs must have special structures in the air to shed their spores. Here fungus threads of Mycelium are growing under the bark of a log.

Puffballs.

which the spores grow and through which they are released. Use a lens. These holes are facing downwards; this allows spores to drop out. There may be another reason to do with the weather. Can you figure it out?

(c) The *gill fungi* have thin partitions which produce the spores.

The mushroom body you see is specially made by the plant itself (which is growing inside a log or a dead tree or in the ground, feeding on decaying materials). It enables the all-important spores to be released free into the air.

Since you will have noticed that it is the cap which usually makes spores, place caps of different kinds on paper. You may find white paper suitable, but other colours may be better for some kinds (the spores come in many hues). Leave your fungus quiet and out of the wind for a day. Gently pick it up. If it was ripe, you will find it has left a pattern of spores. Spray this carefully with varnish or hair spray and you have a permanent picture for your notebook. This is one way in which different kinds of mushrooms are identified. After all, some are poisonous.

If you look at rotting stumps and logs you will be amazed at the variety of fungi. In most cases it does not hurt to collect them. But the beautiful bracket fungi take years to grow. You can see the annual layers quite clearly, including the current one which is producing spores. It is a good idea to leave these for others to see, unless your teacher and you decide you really need *one* for study.

These plants were the first to use sexual union to make new plants. The sperm and the egg are often formed in separate plants. There are often slight differences between plants, as there are between people, so when a new plant is produced, it may quite possibly be different again. It may happen to be different in a way that is important to the plant, that makes it better suited for its way of living and therefore more successful.

This is how new kinds or species of plants have arisen. This is how the great variety of life around us arose. Changes that were not good just died out. But changes that were beneficial stayed on and over millions of years led to

Bracket fungi grow on a dead aspen killed by ringing—cutting away the living layer all around the tree—to make way for pines.

Male, pollen-bearing flowers of pine die away after shedding.

The small fleshy female flower develops into a woody core.

the flowers, fruits and countless other interesting things of the plant world.

3. POLLEN-MAKING PLANTS

Watch evergreen trees in the Spring. You will see them produce some tiny cones of two kinds. Some are a bright buff colour (pinkish yellow). When these are ripe they will give off a cloud of dust if you shake or jar the branch. Is this a mass of spores? Or what? Many other plants do the same thing. Poplar trees, grass and ragweed all give off great masses of pollen. It is carried in the air to our eyes and noses or to a waiting plant.

If you look at this pollen under the microscope you will find it beautifully shaped. It has a very hard and resistant coat. It is able to float around for a long time without dying. There are only a few female flowers waiting for a grain of pollen. If this lands on their sticky surface it sends down a sort of root and fertilizes the egg cell. This chancy method means that large amounts of pollen must be made and released. In the north where great forests of evergreens live you can find a heavy scum of pollen washed up on river banks. It settles into bogs. Scientists bore into the mud with special corers and find thick layers of pollen grains still there, unrotted. They can tell the plant history of the place for hundreds of years.

These wind-pollinated plants have real flowers, but they are not very beautiful, except maybe under a magnifying glass. They do not need to be attractive.

But they make seeds all the same. A pine cone has masses of flyaway seeds between the scales. These scales we have seen are leaves that have changed their shape some time in their development.

It may come as a surprise to find that birches also have cones and that the seeds are also winged and lie between scales. Chickadees feeding on these cones pull them apart and sometimes let the seeds float away. Which animals attack the hard cones of evergreens? Keep your eyes open. Make a chart.

4. FLOWERS THAT ATTRACT

A flower that spreads pollen by wind is like a shotgun: useful but wasteful. A flower that spreads pollen by using a messenger is like a rifle; it aims right at the target.

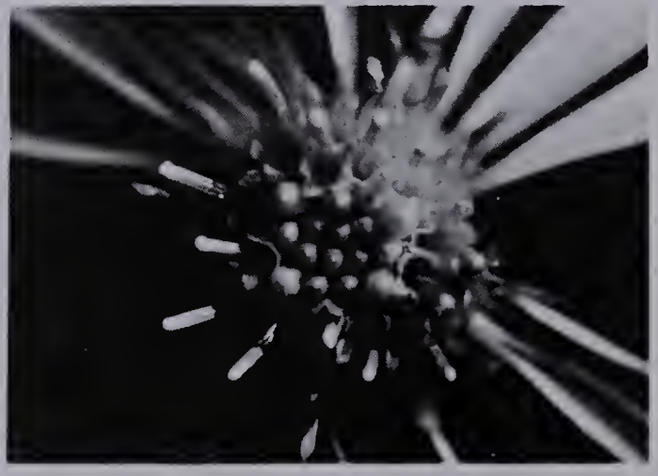
How would you manage to get your parcel across to another plant if you were a dandelion? You would use some kind of messenger. You would have to put up a notice telling about the pay you would give for the job. A pretty flower does just that. Sometimes it does it by colour or shape, sometimes by scent. Sometimes it shows off its pollen, which some insects use instead of bread. In any case some grains of sticky pollen adhere to the insect's hairs and are taken to another flower of the same kind.

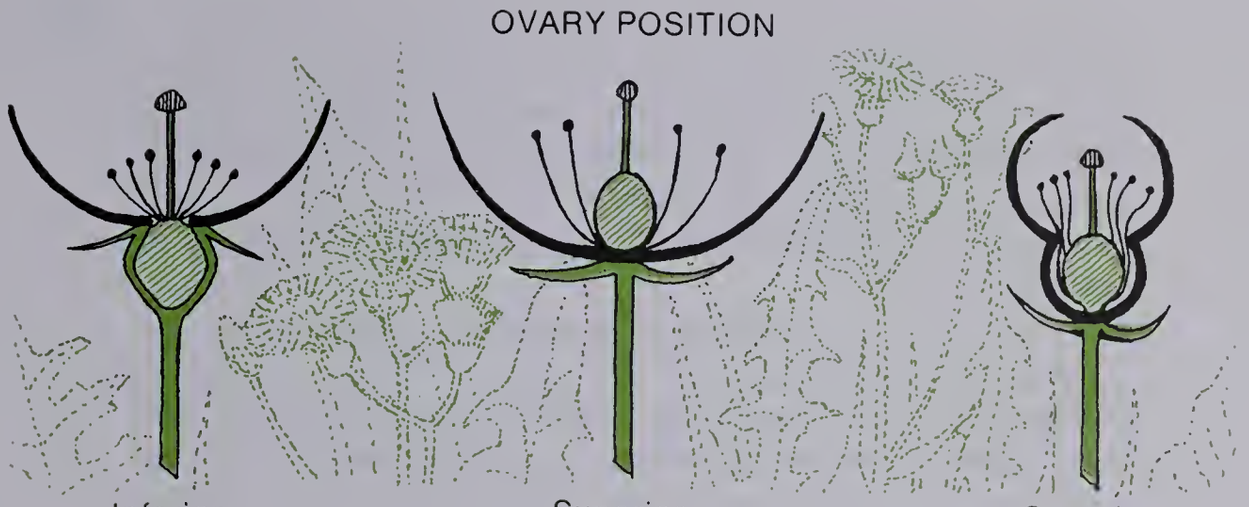
Some flowers, but not all, give nectar. This is usually found at the base of the petals. The advertising points to this with special lines or colours. Look at flowers for this. Even those which do not seem to be good advertisers may be—to insects. These animals' eyes do not see the same light wavelengths as ours. They can see ultra-violet light. If you place some dull-looking flowers under this light you will often find their patterns quite different.

Red flowers look black to insects. What visitors might they attract? Are there other pollinators besides insects?

Flower of New York Aster. The showy ray flowers are sterile but attract insect pollinators.

Individual flowers in the disc of an aster are perfect.





The way a flower is put together tells us a good deal about its cousins. It relates to what we saw earlier about the way leaves grow (page 51).

When you made giant plastic or paper models of flowers, you found that some have separate petals and some have petals joined together. The number of petals also varied. In some cases you may have found that a "flower" was really a collection of many tiny flowers. A dandelion is one example. What others can you find? The position of the seeds is important. These are found in a special pocket called the ovary, and this may be either on top of the ring of petals or below it. Look at a number of different flowers and list them in two columns according to this peculiarity. Be careful. In some plants the petals are attached below the ovary but they curl closely around it and then spread out above it. We say the ovary is *superior* or *inferior*. (How does this meaning fit our usual meaning for these words?)

This ovary becomes the fruit or at least some sort of protection for the seeds. We have various names for these. Some you already know, but others will be new to you.

A pine seed has no such covering. It is a bare-seed plant, or *gymnosperm*. (In ancient Greece the men did their gymnastics bare!) The pine seed is protected only by the cone

scales, modified leaves. Other plants' seeds are surrounded by hard or prickly coverings. But in some cases the shell is soft and tasty. Why? What do you do when you find a wild strawberry? What happens to its seeds afterwards? Is this an advantage to the plant?

So you can see that there are two ways of looking at seeds and fruits.

(a) One has to do with the way they are constructed, the way they develop from the flower. This is useful in helping us to classify plants, since plant relatives tend to have much the same kind of arrangement. You "take after" your mother or father in some recognizable ways. Often a boy looks almost exactly like a photo of his father at the same age (though not always—he also has a mother). Sometimes there is a likeness to his great-grandfather or great-uncle or some ancestor from 'way back.

(b) The other way of looking at fruits is by their use or function. Berries and keys and burrs are ways of sending the seed to a new home. We shall look more at this in Chapter 16.

Collect some examples of fruits and seeds from wild plants, from garden plants, from a farm, from a supermarket produce counter. Study them. Try to group them under headings.

A pumpkin, a cucumber and a squash look different in size, shape, colour and pattern. Find ways in which they are the same.

Examine seeds from each one carefully. Split them apart. Find the beginnings of a new plant in each. Are there other plants which might be in the same family? Compare sunflower seeds. Then compare the flowers. Do you think they are related? What relatives of the sunflower do you know?

The many differences in seeds make them interesting to see. You can use them to make designs. They also usually have thick or hard coats and they last a long time. Why is this? What is the job of a seed? Plants need seeds in order to overcome the difficulties of which one of our seasons?

Make a Seed Plaque

A cedar shingle makes a good base. Think of a picture. Stick different seeds to make this in three dimensions on your shingle. Varnish the whole affair afterwards. It can hang on your wall, looking very professional.

One Way of Looking at the Plant Kingdom

The way cells are arranged in a plant divides them into two great sets. Look at a mushroom under a microscope (100 ×). Take slices from it in various directions. What arrangements can you find in the cells? Do they seem to do different jobs? Are they of different shapes? Do some support the plant, like the woody cells of a tree? Can you find sap channels? How does all this compare with the cell arrangement you have seen in a cattail leaf, a horsetail stem, a slice of a young twig?

In most places you can find lichens growing on bark and fenceposts. Examine these in the same way. You will have discovered that in some plants the cells are all much the same, no matter where they are in the plant.

In the others there are special cells which support the stem; cells which carry sap up or down the stem and inside the leaves; there are skin cells and palisade cells which carry out photosynthesis; cork cells; wax-producing cells; and special cells in the roots with thin hairlike pieces sticking from them to take up water and whatever is dissolved in it.

Those plants which have sap channels or vessels are called *vascular plants*. The others are called *thallophytes;* they include fungi, algae, lichens, liverworts and mosses. Vascular plants vary a good deal. There are simple ones which do not have flowers but produce spores as we have seen. These are the *bryophytes*. We call them horsetails, ferns, etc.

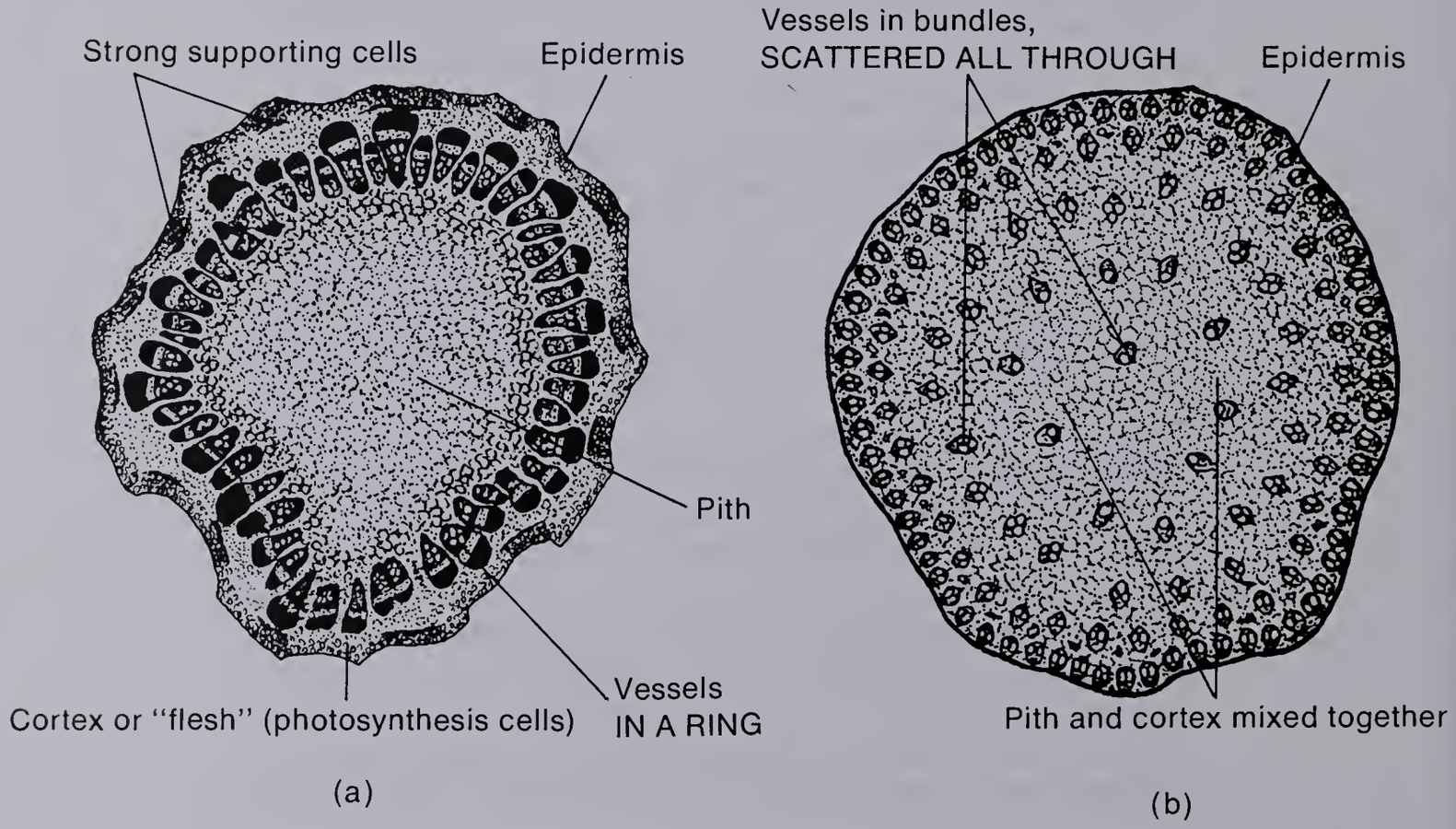
Flowering plants are grouped into two sets, those with "naked" seeds (mostly the coniferous trees) and those with

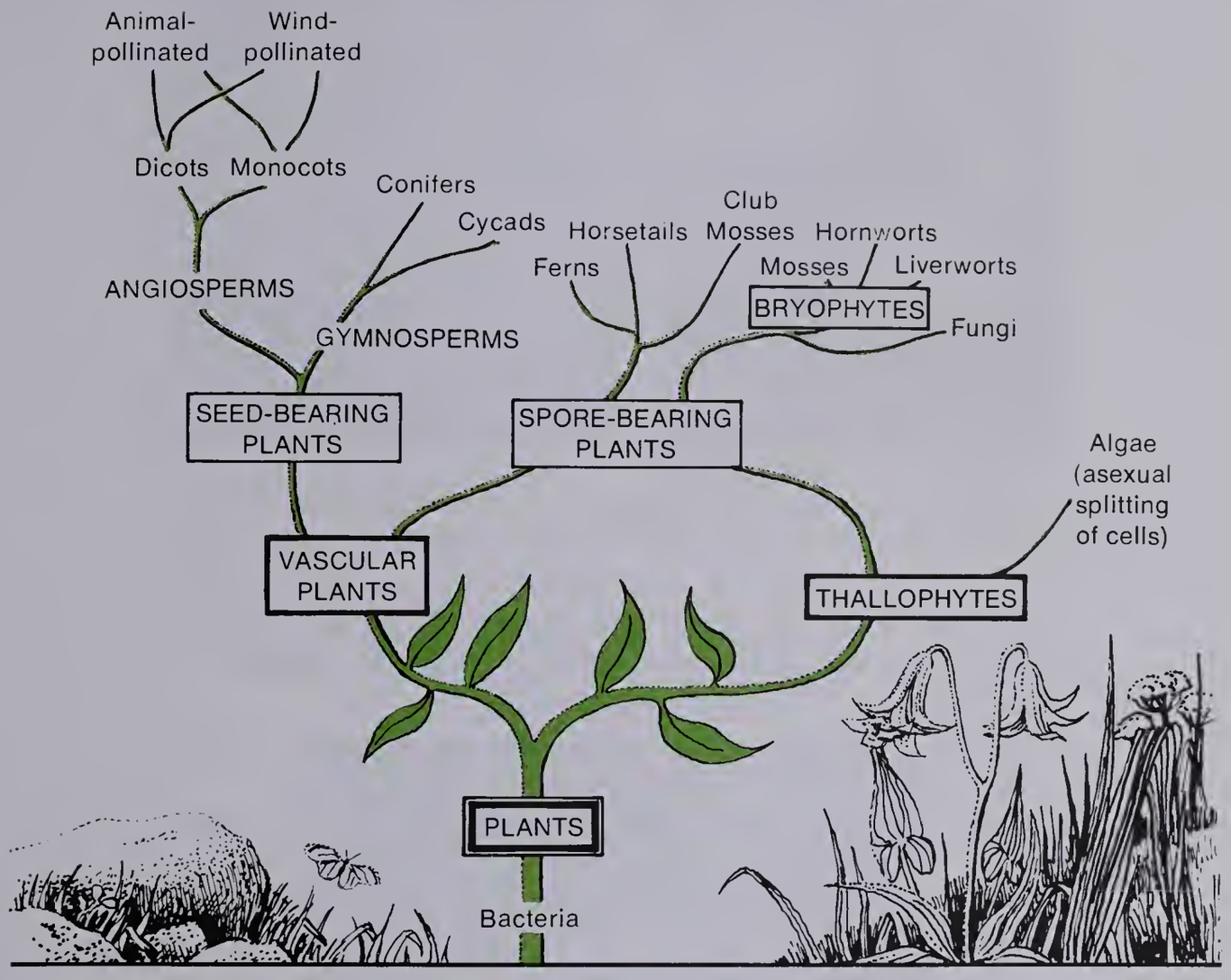
a protective covering for the seed. (See page 97). Cell differences between these can be seen only with a microscope.

The *angiosperms* (the second group) are easily divided into two. Grow a maple seed (or a bean will do nicely again). The shoot has two early leaves which came from inside the seed. Now do this with a seed of corn or onion. The seed has only a single "leaf" (we call these seed-leaves *cotyledons).* Try to find the cotyledons in various seeds. So we have *dicots* and *monocots.* (What do "di-" and "mono-" mean?) The cell arrangement in stems of these is quite different.

(a) Cross section of a Burdock—a Dicot.

(b) Cross section of a stem of Corn—a Monocot.





HOW MANY KINDS OF PLANTS ARE THERE?

Here is a rough count:—

Blue-green algae	7 500	
Fungi	80 000	
Other algae	20 000	
Bryophytes	9 000	(liverworts)
	100	(hornworts)
	14 500	(mosses)
Vascular plants	250 000	(ferns, etc.)
	1 000	(clubmosses, etc.)
	25	(horsetails)
	550	(conifers)
	60 000	(monocots)
	190 000	(dicots)
(Estimated) TOTAL	632 675	species (plus bacteria)

Chapter 16

FILLING EMPTY SPACES

If you look at a raspberry tangle, you can imagine what would happen if each fruit just dropped to the ground. How many seeds does a raspberry fruit have (on the average)? How many berries does a raspberry plant bear in a season? Supposing all these seeds grew, what would the result be? Overcrowding, yes. But what does this mean in detail? There is available only so much of each of the things plants need to live. What are these? What does happen to many raspberries? to their seeds?

Find a piece of ground where all the vegetation was removed some time ago, but which has been left alone since then. An old sandpit, a road shoulder, or an old field are examples. A rotting log is another. Plants have started to grow there again. But where did they come from? Here are some answers. Find examples of each.

1. Roots were still there, beneath the surface. These sprouted.
2. Roots tunnelled under the surface from nearby plants and sent up shoots of new plants.
3. Seeds grew that were hidden in the soil, perhaps for years, waiting for the right conditions.

Take some soil from a bare piece of ground, some from the surface, some from 5 cm down, 10 cm down, and 15 cm down. Spread them out separately in 1 cm layers. Water carefully. Record what grows.

4. Spores floated in. We have talked about this.
5. Seeds parachuted in.
6. Seeds flew in on wings.
7. Seeds hitchhiked in on fur or clothing and were dropped here. You see your dog scratching and nibbling these burrs out of his fur after a walk. How many kinds can you find?
8. Birds, raccoons or other animals ate berries or choke cherries. The seeds passed through their digestive systems and were dropped.

A fountain of Thistledown.

Poisonous berries of Baneberry are sometimes called dolls-eyes.

Lines of rushes on a fresh-water beach show where underground roots (rhizomes) have spread.

9. Birds carried fruits or seeds to eat later but accidentally dropped them here.
10. The wind blew seeds or pieces of plant in, or water carried them in.
11. Plants crawled into the area with long runners, putting down roots wherever they found a suitable place.
12. A plant shot them in! (Hint: look for a jewelweed in August.)
13. Look for other ways.

Collect as many different kinds of seeds and fruits as you can. Note whether the plant was tall or creeping; whether it grew in an open place or a thicket; whether anything seemed to be using the seeds or fruits (one of our common birds lines its nest with plant parachutes).

Now record your findings, perhaps using simple drawings or descriptions. Then against each put what you think is its method of distribution. The names of the plants are not too important. But once you have discovered how they spread, you may like to know what they are called.

You could make a chart something like this. (The third column uses a simple picture for each method; you need a key to explain this.)

You can group seeds in other ways:

Size (What is the largest seed you know? You can sometimes buy it at the supermarket; it is hairy. How does it spread to tropical island shores?)

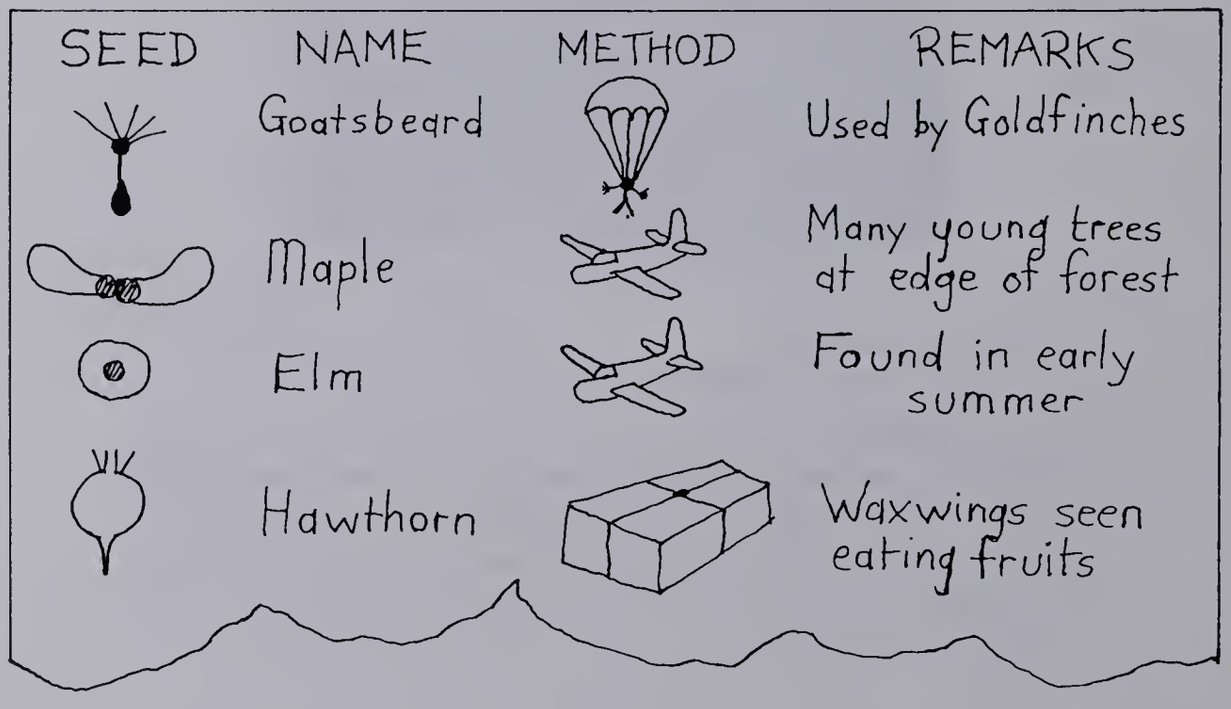
Weight

Shape

Texture

Scent (Crush to smell.)

DO NOT TASTE ANY SEED UNLESS YOU KNOW IT IS HARMLESS. SOME ARE EXTREMELY POISONOUS.



Chapter 17

BRRR IT'S FREEZING!

We like the winter for certain things, like snowballing and tobogganing. But have you ever gone out in wintertime to look at what has happened to plants? In the northern parts of the world, and the far south too, life is hard for plants in winter. Yet they have to carry on in some way. We want plants to be there again next summer, producing peaches and football fields and colourful garden flowers. Different plants get over this problem in different ways.

First, let us look at the problem. Is it the cold? How does that affect plants?

1. Fill one screw-top glass jar with water, another with strong brine, a third with the antifreeze mixture you use in a car radiator. (These mixtures are poisonous.) Put the caps on tightly. Be sure each jar is quite full. Set these jars outside on a really cold night or in the freezer. What happens to water when it freezes? Imagine what would happen inside a plant cell. Is there a possible way the plant could overcome this problem? Many plant cells live unhurt through winter. Many insects do the same.

2. We have already discussed the movement of water in a plant. It is given off by the leaves. Where is it replaced? Drink some water with a straw. Now replace the water with ice cubes. Try to drink it.

   The problem with winter is *drought*.

3. If you catch a butterfly on a warm day, it is very active. Place it in the fridge for a time. This will not kill it, but it will slow it down. Root cells are slowed down by cold and cannot work as well. (We and other warm-blooded animals are different because we make our own temperature by burning food; our body has a thermostat, too.)

   Plants get around all this in various ways:

(a) What do a maple's leaves do in the Fall? Why?

(b) How do we explain an evergreen's leaves? Look at a pine needle carefully. Where are the stomata, the little pores where air and moisture vapour pass in and out? Can the leaf cover these in winter? If you go in a conifer forest, you will notice a rather pleasant but strong smell. Find a tree which has been injured in some way. Something has healed it. We call it gum or resin. Cedar trees have an oil. Crush some cedar leaves and sniff. Evergreen leaves have a layer of this waterproof material just under the tough surface. It prevents drying out. You can obtain some of this material from the blisters on the bark of a balsam fir tree. It is a clear liquid. How would you describe its scent? Spread some on paper. Be careful not to get it on your clothes or hair. Let it dry. Is it really waterproof?

   This gum is pure and clean. It serves also to protect tree wounds from infection by insects, or germs or spores, which float in all air. It was once used as a seal and salve for cuts in people.

   Questions: What are the advantages and disadvantages of the two methods, broadleaf (deciduous) and coniferous (evergreen)? Do evergreens hold their leaves for ever? How long? (Look at a young tree for the answer.)

What happens to the fallen leaves, the tree's garbage? Have you heard of *re-cycling*?

(c) Many plants do not live over winter at all. The salvia of our gardens is one. How do they carry on, these *annuals?* If a farmer wants to grow more oats next year, what must he do? (We have warm spells in winter quite often. If seeds germinated then they might be killed by the next cold snap. Most seeds must pass through a certain period of cold before they will sprout.)

(d) If you look in waste places, and even in your lawn, in late Fall, you will see a number of *rosettes*. Can you identify any of these? Dig up one or two and look at their roots. These are *biennials*. How many years, then, do they live? (How many circles does your bi-cycle have?) These plants have a longer time in which to make the food supply they need to produce seeds. Where do they store this food over winter? Many of you have seen maple syrup made. Where does the sugar come from? Why is it passing up the trunk at that time of year?

These rosettes avoid drying out because of their form. How? Some are covered thickly with hairs. Is this fur to keep them warm, or can you think of another reason for it?

(e) Many plants live several years. We call them *per*ennials. (*Per*spiration is different from respiration in that it goes *through* the skin.) Their tops die down each year, usually, in our climate. Which part of the plant lives on? Dig up a plant of goldenrod, or watch a gardener forking over his perennial bed.

You may now have some idea how Arctic plants manage to survive. They often take many years to grow into even a small plant, or to produce flowers and seeds. They are usually low to the ground, too.

The temperatures and moisture of winter and summer, plus some other things, make up our climate. But there are mini-climates (microclimates).

1. On a sunny day, winter or summer, take temperatures in the sun and in the shade, at different heights above ground, even below ground level.
2. Place thermometers on squares of sunlit material of different colours on the ground: white, black, red, blue, metallic. Take readings.
3. Place the thermometers under the materials in number 2 and read them.
4. Suspend the thermometers 5 cm above the materials.
5. Use a wet-and-dry bulb thermometer (humidimeter) outdoors. If the air is rather still, fan the bulbs strongly.
6. Take temperatures on slopes facing towards the sun and away from it. (Try shielding the bulb itself from direct sun.)
7. Take temperatures on top of a hill and down in the valley, in dry places and beside water.

Compare plants found growing:

(a) in shade and in the open
(b) on north and south slopes
(c) on hilltop and down by the stream

Make lists. Try to find evidence to explain your findings.

We found earlier that the big problem of winter is dryness—air is dry and sucks up moisture, especially when warmed. (Furniture in a house dries out in winter. We install humidifiers.) Water is not to be had. It has turned to stone.

In some climates, and in some years almost everywhere, the summer is dry. Our lawns begin to dry up. Trees start to turn, or their leaves drop off. In deserts this is a regular thing. Winter may be the time of cool and moist weather. So plants hibernate in summer ("aestivate") as ours do in winter.

In tropical forests, fallen leaves and plants rot very quickly. Tree roots must be near the surface to take up the food before it evaporates or is washed away. Defoliation, such as is being done in Viet Nam, lets in the hot sun. It dries up the forest floor, including the roots, and kills the trees. It may be hard to get a forest to grow again.

Chapter 18

THE PLANT COMMUNITY

We have suggested several times that plants growing in one place may be different from those in another where conditions are different. It sounds reasonable. But let us test it.

"Key" plants

Choose a number of different kinds of areas. Try to pick one or two "key" plants from different areas which could be used in a descriptive title. (We talk about a beech-maple forest.)

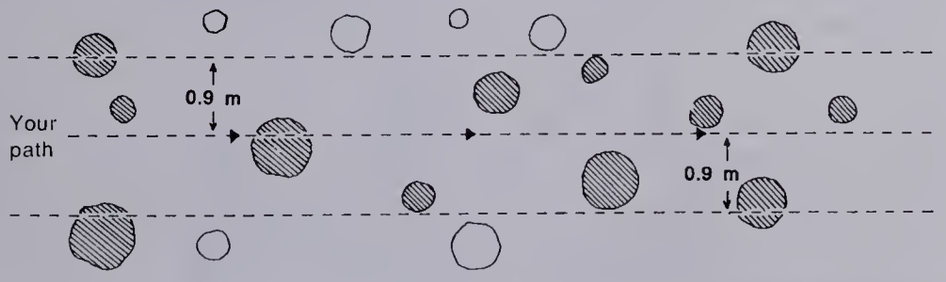
There are a number of census methods used by scientists. They save time and energy, but they are designed to keep results as accurate as possible.

1. Plot censuses.

The composition of an area of vegetation may be important. This means not only the kinds of plants but how many of each. *Studies for Open Places* shows how to use various methods for making this kind of census.

2. Line transect.

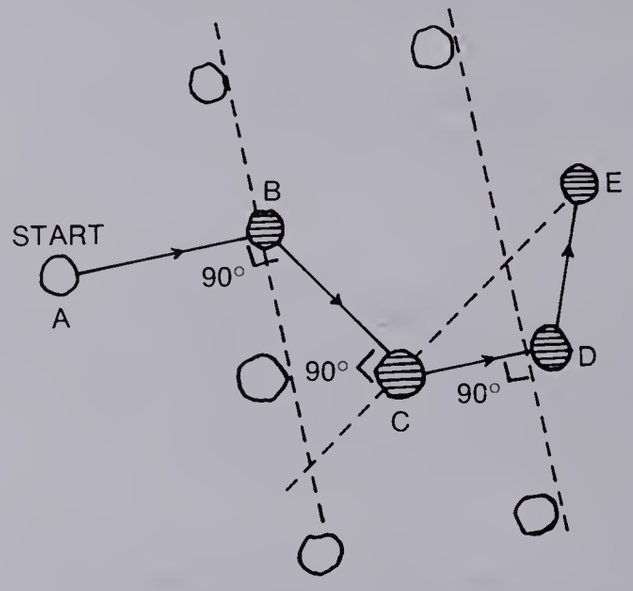
This is useful in a woodlot. Walk a straight line from one side to the other. Hold a metre stick in each hand; these are hinged together. When one touches a tree, this is recorded. You then lift up that end of the metre stick to allow you to pass and then let it down again.



What you record is up to you. It might be the number of trees in each 10 km^2 section or the diameter of each tree's trunk at breast height; or the species; or the heights of the trees (see later for a method of obtaining this). What is the smallest tree you will record? Decide.

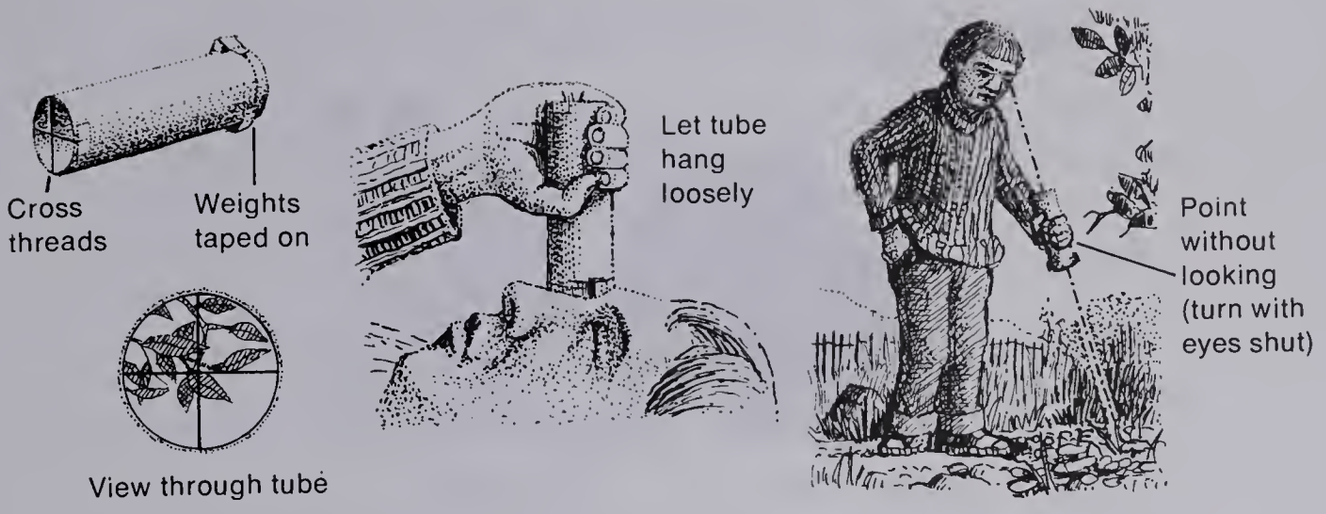
3. Random transect.

This is a variation of number 2. It is rather fun to do. Choose a starting tree (A). Then pick the nearest tree (B). Tree (C) is the nearest one to (B), but the other side of a line drawn through it at right angles to the line from (A). The sketch will make this clear! Go on to (D) and the rest of your series in the same way.



4. Canopy cover survey.

Use method number 3. Measure the amount of sky obscured by the leaves. Use a cardboard roll with threads taped across one end to cross in the centre. Hang a weight from the other end so you can let it hang upright. You record (+) if the cross-threads are on foliage when you look up through; (–) if they are not. Take a sighting every other step for 20 steps. You may want to do this in more than one part of your study area. By holding the same tube at random in front of you and facing towards the ground, you can obtain a figure for ground cover too.



5. Basal area.

This is the amount of ground actually covered by tree trunks. By a random transect you can get the average distance between trees. From this you can work out the density per hectare. Divide the number of m^2 per hectare (you work it out!) by the square of the average distance between trees. Knowing the size of tree trunks will then give you the basal area per hectare.

To measure the area of a tree trunk, you must know the diameter. There are various ways of doing this.

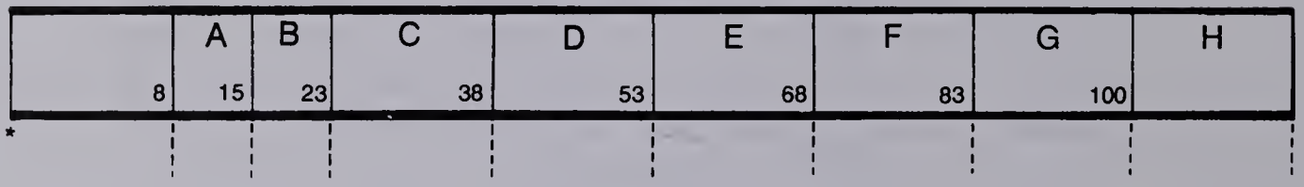
How To Find The Area of a Tree Trunk

(a) Measure the circumference with a tape measure. Divide circumference by 3 1/7 ("pi").

(b) Make a sliding rule, using a metre stick.

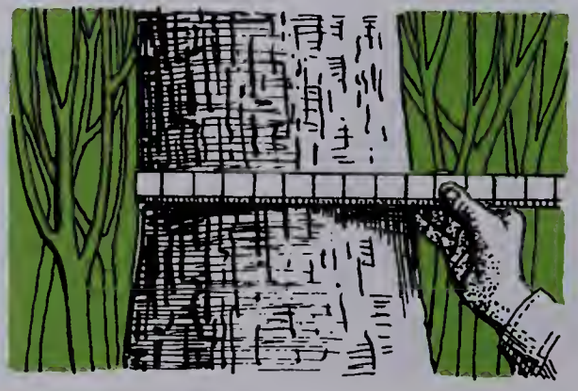
Fixed Right angles This slides

(c) Make a reach-stick by making new marks on a metre stick. This will give you "size classes" rather than actual measurements for each tree. But this is usually quite good enough.



TREE DIAM.	8 cm	15 cm	23 cm	38 cm	53 cm	68 cm	83 cm	100 cm
DISTANCE FROM* (end of ruler)	7 cm	13 cm	19 cm	29 cm	38 cm	45 cm	52 cm	59 cm

Hold the stick up level at arm's length, and touching a tree. With one eye open, align left end of reach-stick with left side of tree.



Read where the right side comes without moving your head. This will give you the diameter of the trunk.

Once you have the diameter, you can use a simple formula to work out the area. Again, check with your teacher if you are not sure.

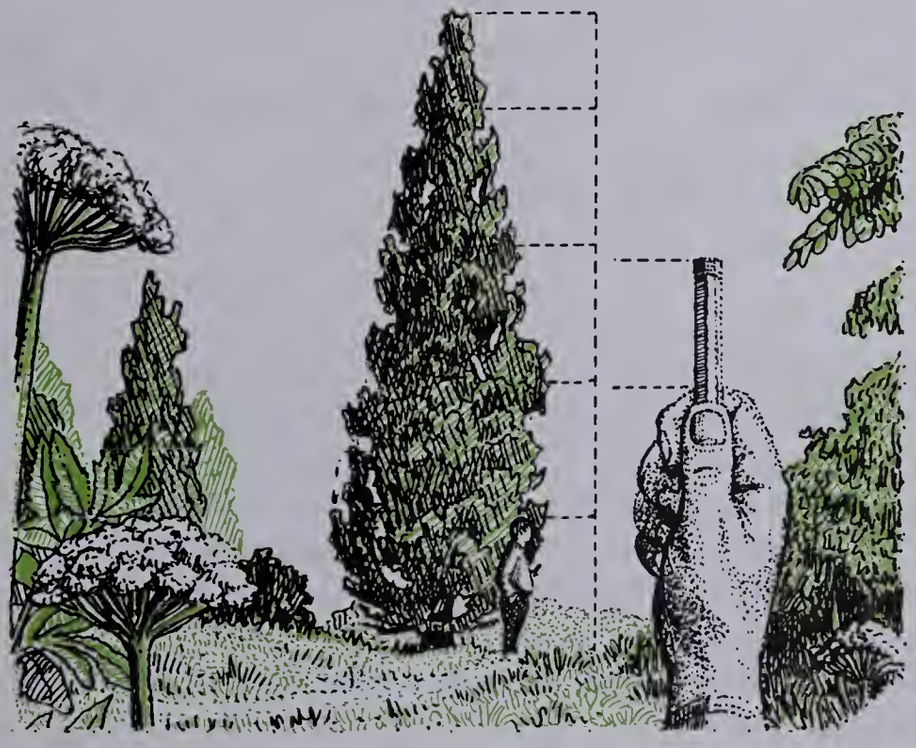
You could measure 18 m from a tree by hanging another metre stick in the tree. How? Use your reach-stick.

A circle 18 m in radius is 0.1 ha. This is a useful area for census-taking.

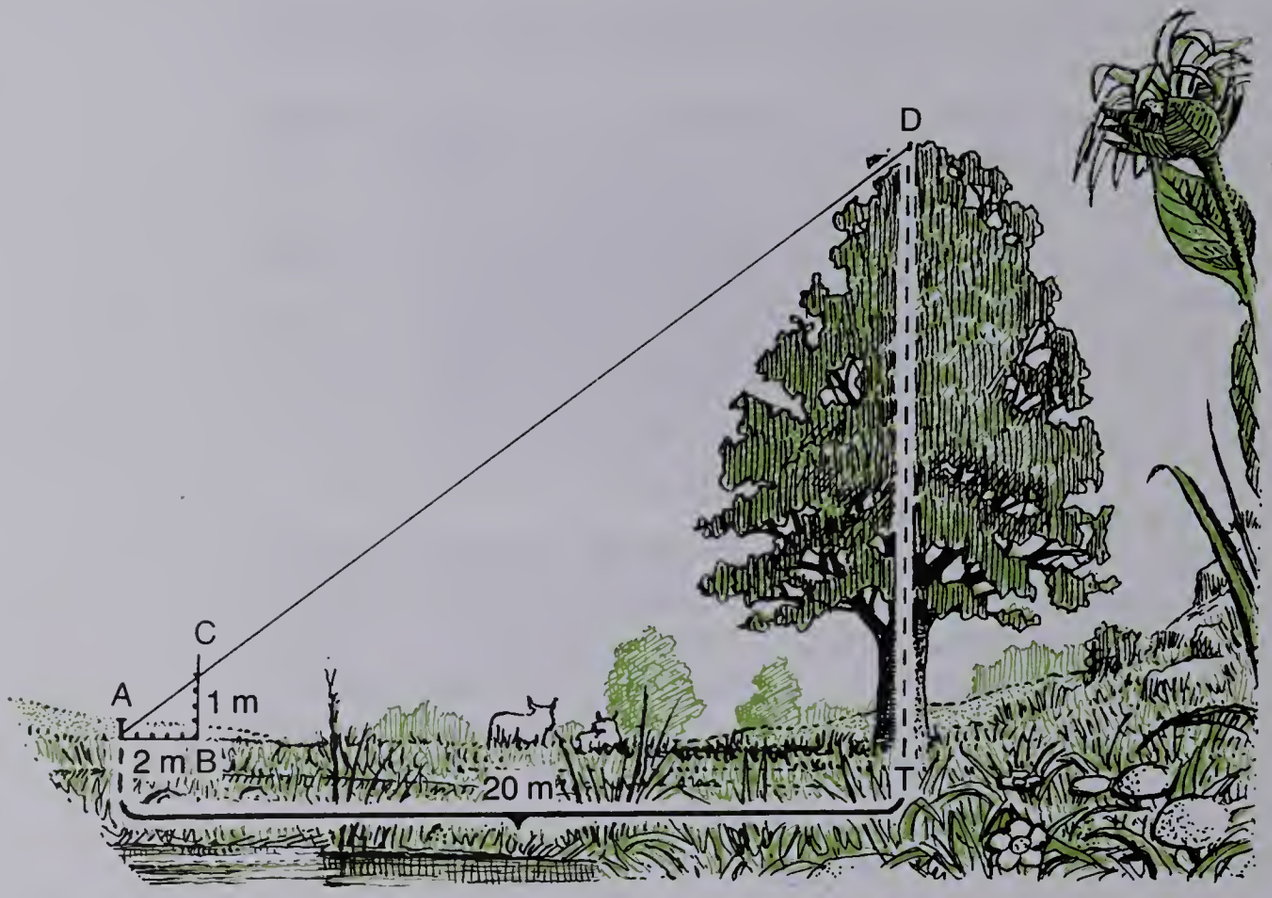
6. *Height of trees.*

There are several ways:

(a) A rough estimate can be made by having someone whose height you know stand at the foot of the tree. Stand some distance away and hold your hand at arm's length. On a piece of stick mark with your finger this person's height. Now see how many times that distance goes into the height of the tree. Why is this not quite accurate?



If a boy is 1 m tall, tree is approximately 5 x 1 m = 5 m

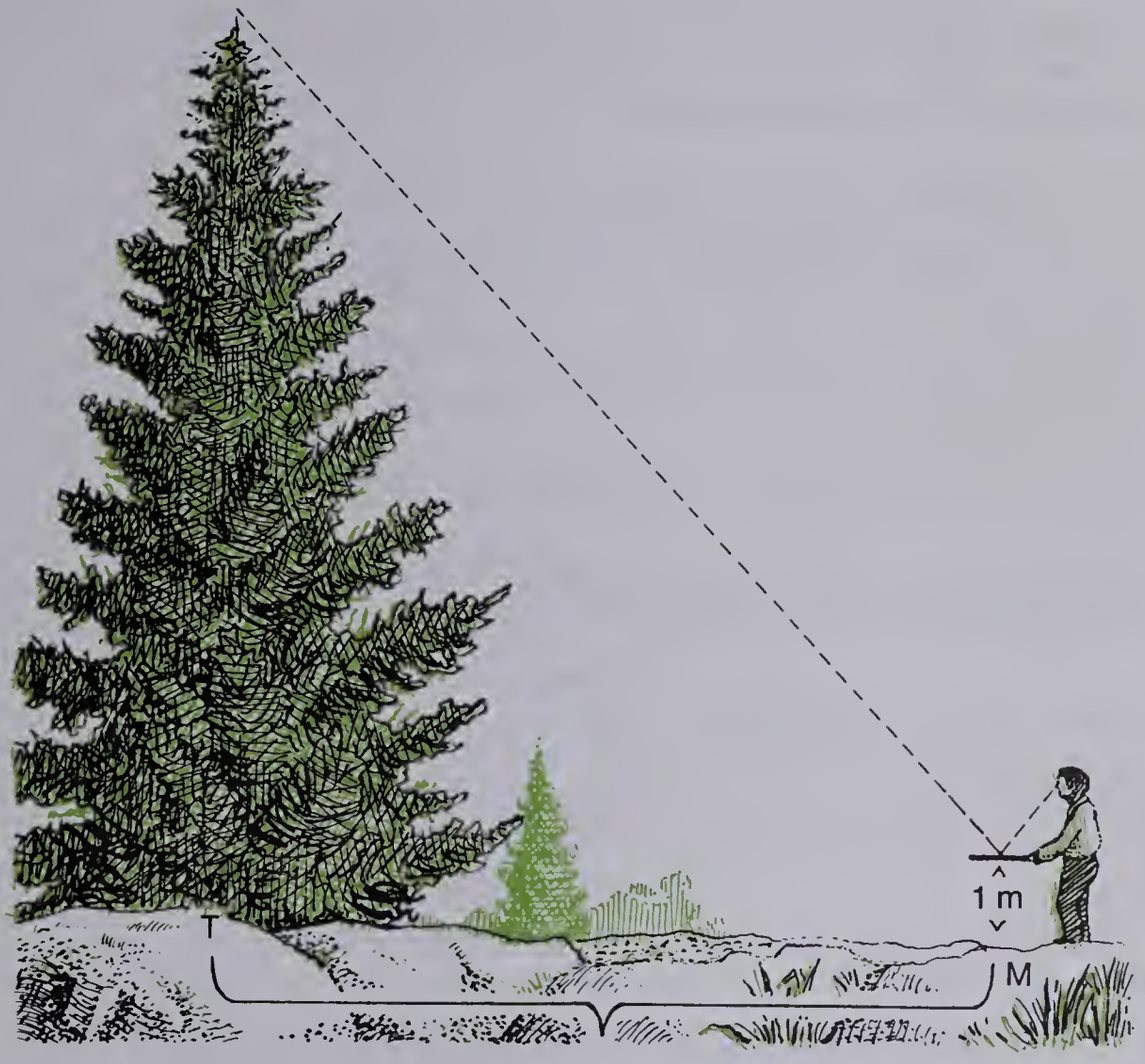


(b) AT = 20 m
AB (to upright metre stick) = 2 m
Ratio AT : AB = 10 : 1
So height BC (to where line of sight to top of tree passes stick) is to height of tree as 1 is to 10 ck)

$\therefore$ tree is 10 m high

$$\text{Or } \frac{DT}{AT} = \frac{BC}{AB}$$

(c) A similar method but easier to handle uses a hand mirror to which a level has been taped so that it can be held horizontal. Hold the mirror out at arm's length one metre from the ground. Walk towards the tree until its topmost point appears in the mirror. One metre, plus the distance from mirror to tree, equals the tree's height. Simple, isn't it?
Try all three methods and see how close they come to each other.



Height of tree = MT + 1 m

Now you have a number of tools. What are you going to do with them? Here are some suggestions. You will think of many others.

1. Make a vegetation profile of a valley from hilltop to streambed to hilltop. This will show effects of various microclimates on plants. You may wish to make a slope survey also; or dig holes at intervals to find out how deep soil moisture is; or record temperatures at certain times of day, etcetera.
2. Plot the way vegetation changes from the centre of a pond, in open water, on the banks. How do the plants grow, flower, seed? Research water celery *(Vallisneria),* duckweed, stonewort.

3. Record sample plots in a woodlot—centre, north edge, south edge, etcetera. Canopy, ground cover, height, kind of plant are all important.

COMPETITION AND ADAPTATIONS

In your community, which businesses are competing against each other? What does "to compete" mean? It means there is a limited amount of something. Businesses are looking for customers. How do those you chose compete against each other?

What do plants compete for? We have answered this earlier.

How do they compete? Let us look at *light*. How do the following plants compete for the available light?

	Clues
dogtooth violets in a woodlot	time
a maple tree	leaf mosaic, trunk
a wild grapevine	tendrils
a strawberry	runners
a waterlily	escape to water
a dandelion	smothering leaves
bedstraw plants	hooks

These plants compete by *adaptation*. It is very important indeed. We have talked about it often in this book, though we did not always realize it. Different ways of pollination, of seed dispersal, of over-wintering, of places to live, of tropisms—all are adaptations to something.

You can find clues everywhere. Try to answer these questions:

1. What is the difference between two trees of the same species when one is grown in a wood and one is grown in the open?
2. How are a waterlily's seeds dispersed? Where are the stomata on its leaves?
3. Why do some plants catch and "eat" insects?
4. Identify three climbing plants and the differences between them.

5. Why are some flowers, such as in the wild carrot, massed together?
6. What has happened to the stem, leaves, shape of a cactus? Why?
7. Why is there no ragweed in northern Quebec? Is it a long- or short-day plant? What is the date of first frost?
8. Why does a hawthorn tree have thorns? (Think carefully.)
9. What are the jobs done by bark? Why does it contain cork, or wax?
10. How does air get to the roots and underwater stems of, say, a waterlily or cattail? Examine these plants carefully, using a lens.
11. How do plants prevent their seeds from being fertilized with their own pollen? Examine wild or garden flowers carefully for the answers.
12. How does water-celery pollen reach the ovary?

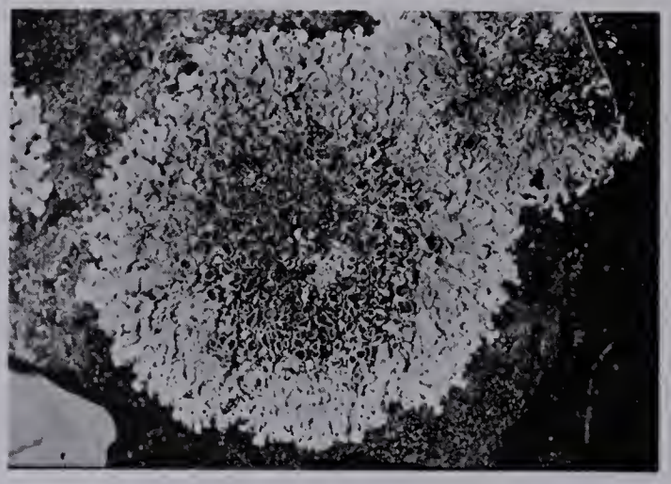
There are thousands of such questions. There is a lot of fun finding the answers, especially when you work them out for yourself.

In Chapter 16 we talked about how plants move into a new area. Once they are there a whole string of events takes place, each of which depends on those that went before. We call this *Plant Succession*.

Plant Succession

(a) Some plants will grow in very poor conditions, where heat is great, where dryness exists for long periods, and where there is little or no soil.

Lichens are the best example. They look rather like mosses, but are usually greyish, even black, orange, or red. If you could see into the cell arrangement you would find that this plant is really two mixed together to make what seems and acts like a new plant. One is a fungus, because cells of fungi can stand long droughts. They just go into a sort of hibernation inside a weatherproof coat which saves the moisture. But



A lichen rosette on a bare rock.

fungi do not have chlorophyll; they cannot make food, but only use what has been made by others. As we said, a bare rock has none of this. The other plant is an alga. It is green and supplies food to the lichen. But it needs water; so the fungus part protects it from drying out. This working together is called *symbiosis.*

(b) Lichens have no roots. But they cling so tightly to rock that when they dry out and shrink they may pull crystals off the surface. This is soil-making. The weather helps too.

(c) This soil is washed down into cracks and pockets in the rock, together with pieces of the lichens and other materials, even dust. Other plants can get a start here. These may come in as spores too. What might they be?

(d) Larger plants with roots can next enter the scene. The roots creep into cracks and grow larger. This may crack open a rock. It allows water in and, as we saw, water expands when it freezes. Roots also give out a chemical (citric acid) which will dissolve some kinds of rock.

(e) As soon as plants start to grow, their stems and roots hold other materials in place—blown leaves and soil, including the old leaves and stems the plants have finished with. The plants' leaves shade the soil, prevent it from drying out, and protect it from the erosion of raindrops and wind.

(f) Finally, large plants such as trees are able to grow. Look for examples of all this. An old quarry or the Canadian Shield are good places.

Chapter 19

THE PLANT-ANIMAL COMMUNITY

With what we have learned, it will come as no surprise that plants and animals are geared to live together. There are endless examples. Finding and recognizing these is one of of most exciting kinds of exploration. Adaptations work both ways.

Insects cause galls in plants. This forest has been burned.

The pileated woodpecker made these cavities.

FOOD

Early in the book we discovered that animals must in the long run get their food from plants. Do you remember why? Find examples of plant foods used by animals. Make them as varied as you can. Think of different parts of plants —*all* are eaten by something or other, even wood or the waste parts that pass right through a plant-eating animal! (Look in a dried cow-pat.)

While plants are mostly made from carbon dioxide and water, there is another part of the air needed for protein construction in a plant. It is the biggest part of the air we breathe. But it cannot be used as it is. It must be made into a water-soluble chemical. A few plants can do this with the help of bacteria (which *may* be microscopic plants—no-one really knows). Plants of the clover family keep these bacteria in little knobs (nodules) on their roots.

You can see these if you dig one carefully and wash dirt off the roots. Some bacteria live directly in the soil and "fix" nitrogen there. Some is fixed in the air by lightning and falls in rain. This material is passed from one plant to another by decay; we have dealt with composting already.

But some places, especially waterlogged ones, will not allow decay to take place. There is a shortage of available nitrogen and other plant foods. Some plants living in bogs have adapted to catch and digest insects. See *Studying Insects*.

Since animals must rely on plants, plants need to protect themselves from being eaten out of existence. They use many ways:

thorns and prickles (But donkeys and goats have leathery mouths.)
bad taste
poisonous substances
holding water on leaf surface (Some animals do not like this.)
high branches (But some animals have evolved long necks or an ability to climb well.)

Find examples of all these.

SHELTER

Also, plants protect animals. Some examples are:

nests in thorn trees and hollow trees,
galls (see *Studying Insects*),
hiding places among leaves (even inside them),
camouflage to look like plants

As well as protection from enemies, plants can provide shelter from the weather. When we discussed microclimates earlier, we found examples of this. Hunting animals use plants too. How?

In winter go out looking for ways in which animals have used plants to hibernate. Clues: look under loose bark

and fallen logs, inside plant rosettes, especially the hairy ones, in hollow trees, inside plant stems such as cattails, under fallen leaves in a woodland, in a rotting stump, and other places.

If we want wildlife, we must make sure it has what it needs. Think of ways in which we can help to preserve and encourage animal life by using plants. Do you think we are using our fencerows and roadsides as well as we might for this? Is it good to clean up a woodlot by removing dead trees, fallen branches and leaves, and under brush?

POLLINATION

Nectar and pollen are food for many animals: insects, birds, even some mammals.

But the plant uses these also to attract animals which will fertilize its seeds. It uses petals, and scent too. This is the reason for the attractive flowers in our world. Differences between them have to do with competition for pollinators:

Plants have a shape which will attract a certain kind of insect (long nectar tube is one example).

Time of flowering is important.

Certain colours appeal more to some kinds of animals.

Orchids are among the most interesting flowers in this way. We have dozens of wild species in Canada. Most are quite small and dull in colour, but their shape is fascinating. Mints and lobelias are worth a look too.

OXYGEN

On a warm sunny day look in shallow pools. Plants under the water will often be covered with bubbles. You know by now what gas this is (Chapter 4).

It is possible to keep an aquarium for years without changing the water. You must find a balance between the water plants which give off oxygen, fish which use it (guppies are easy), light which helps to produce it, and

snails which eat algae. You may have to pull out some of the plant growth when it becomes too thick and cuts off light. And you must add water when this evaporates; but use it from a clean stream or well. The chlorine in city water will spoil your project.

Animals are using up oxygen all the time. Decay is using it up too. All plants and animals die in the end and have to be recycled. All the oxygen we need is supplied by plants.

It is possible to keep a mouse in an airtight container with growing plants. Some large science centres have these on display. If you wish to set up such an experiment, write to them.

SEED DISPERSAL

This has been mentioned earlier in Chapter 16. Animals are an important part of this picture. Squirrels often plant oak trees by forgetting!

WATER

Many animals never drink water. In what sort of country do you think these animals live?

Weigh out 0.5 kg of green leaves. Spread these out in the sun or in a stove at 43°C, so that they dry. They will be brittle. Do not let them rot or scorch.

Weigh them again.

Try this with leaves from a dry place—grass perhaps; try it with those from a wetland—jewelweed is a good example. Compare your results. Now you know where the water comes from that animals need. But in a desert, plants may have very little water in them at certain times. Some animals that live there are able to *manufacture* water in their bodies from the plant materials they eat. This is different from *extracting* it. The attractive gerbil is one dryland animal which can do this. Do you know where it originally came from?

For the important matter of food chains and pyramids, see *Studying Insects,* Chapter 6.

The famous Charles Darwin once said that he believed the amount of clover in the fields depended on the number of old maids in the community. It sounded like a joke, and maybe it was; but he explained it like this: old maids keep cats; cats eat mice; mice eat bumble bees; bumble bees pollinate clover flowers; fertilized flowers produce seed. (And someone added that clover is used by cows to make beef; beef is eaten by sailors and makes them brave; so the old maids of England were responsible for the defence of the Empire!)

COMPOST

Plants die. Animals, which are made from plants, die too. They do not just pile up. What happens to them? The materials of which they were made are turned back into substances that plants can use. They must be soluble in water for one thing.

Many agencies help in this. The weather helps, mainly by providing conditions in which tiny organisms, bacteria and fungal spores among them, can operate. Woodpeckers produce wood chips which rot faster. (Why?) Some insect larvae chew wood or fallen leaves into powdery pieces. Bears break open stumps to get at the insects. Worms carry dead leaves underground. Mice and gophers line their holes with grass or other plants. It all helps.

Gardeners often help by making a compost heap of unwanted plant materials. You could make one.

From what you have observed in the wild, say, on a woodland floor, or in a corner of the schoolyard, try to decide what conditions would be best for turning your plants into that lovely, crumbly, rich brown material we call compost. Another name is humus. (See *Studying Soils.)*

Chapter 20

THE PLANT-MAN COMMUNITY

Man is an animal too. We like to think sometimes that we are a very special kind of animal, but we need the same sorts of things that other animals need.

We need to *breathe*. Do you know how many acres of land in North America are paved or covered with buildings in one year: 2 000, 20 000, 200 000, 2 000 000? Think of the effect on the oxygen supply. (Herbicides are now a weapon of war. Why is this? Many people are concerned about what would happen if a ship loaded with them sank on its way to South-East Asia. Ocean plants supply a large part of our oxygen.) Is there any effect on anything else?

We need to *eat*. As with every other animal, all our food comes from plants in the end. But there is a difference. Let us look at the history of food.

(a) Think of the most primitive tribe you know or have heard about. How did they obtain their food, clothes, etcetera? Read the story of Robinson Crusoe.

(b) Some animals, when captured young, become quite tame, and useful. Some could be a help in hunting. Others just produce meat, and some other things. What are these? They made these from plants. Men who kept domestic animals like this were always on the move. Read about Abraham in the Old Testament. Also read about Nimrod, Esau and Isaac, and many others.

(c) Wild plants can be very useful when you are travelling. But they may be scattered all over. It is much easier to grow them together in one place. The development of agriculture made a tremendous difference to people. It made towns possible. People had better homes, and they had time for other things.

For a few years at first it was cut, burn, plant, reap, and move on. But soon people learned how to care for the land. They learned that the land must be fed; that growing the same crop every year was bad for it. Each kind of plant takes different amounts of things from

soil. Some put back nitrogen. Plant pests and diseases grow stronger when one crop is grown all the time.

Choose four different field crops grown in your area. Make a time table or calendar type of chart with a column for each plant. Try to arrange these farm operations in the right order for each plant. In some cases there are different ways of getting the same result. Corn, too, is used for at least three different things, and the time table will be somewhat different for each. Show all this in a chart. (In some cases the name of the implement is used.)

PLOW FERTILIZE ONE-WAY DISC GANG-DISC
CULTIVATE PRE-EMERGENT WEED SPRAY
SWATHE CART BALES HARROW STOOK
CHOP AND BLOW SCUFFLE PICK MOW
COMBINE BALE THRESH BINDER
SIDE-RAKE MANURE-SPREADER
Add others if necessary.

We know that children, even in one plant family, are not alike. By carefully choosing seeds from the kind of plant we want we can help this situation; but it really works best with plants we sow often and which take only a short time to produce a crop.

Apple trees are something else. In some parts of the country wild apple trees are common along fences and in neglected fields. If you have tried these you know that few fruits from them are worth eating. Birds have spread the seeds in most cases. But if we take a part of a plant and grow it we get the same plant exactly. Bananas and sugar cane are grown like this. What is sown in each case? You can try it with cuttings of geraniums.

Orchardists need their fruit to be uniform. (What does this mean?) Certain varieties have been bred for the qualities people want. What are these qualities?

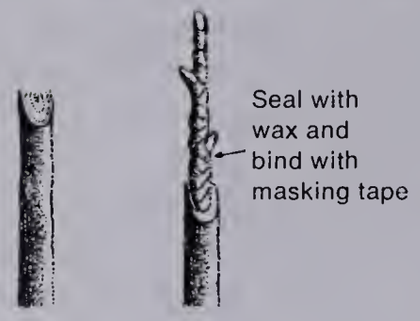
Collect apples of as many kinds as you can find. Record their names. Test them for many qualities: colour, firmness, tartness, toughness of skin, scent, keeping qualities, ease of bruising, cooking quality, etc.

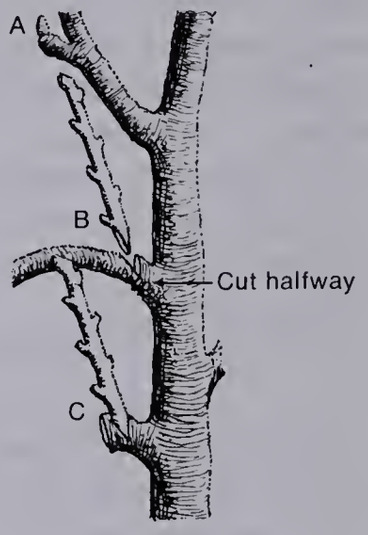
For a uniform orchard, we graft pieces of good trees

on stumps of worthless ones. Here are some ways of doing this. Try them. It does not really matter what kinds of apple you use since you will learn something about how plants grow. You could use hawthorn or wild cherry, since these are cousins of our cultivated fruit trees.

Grafting

(a)





(b) Three stages in a stub graft:

1. Suitable branch.
2. Branch cut and bent.
3. Graft pushed in and branch cut back .

We need *clothes, homes* and many other things. As we found in Chapter 1, page 3, we use plants a great deal and in many different ways.

Find out the following information: Make a chart in your notebook.

Object	Plant Used	Part of Plant	Where grown
Doormat	coconut palm	husk (coir)	tropical coasts
Paint			
Floor Wax			
Honey			
Cider			
Attar of roses			
Coal			
Currants			
Turpentine			

Object	Plant Used	Part of Plant	Where grown
Rope			
Tea			
Margarine			
Cloves			
Bran muffins			
Eraser			
Ink (formerly)			
Axe Handle			
Kapok (Life vest)			
Vanilla			
Shopping Bag			
Lauan Plywood			

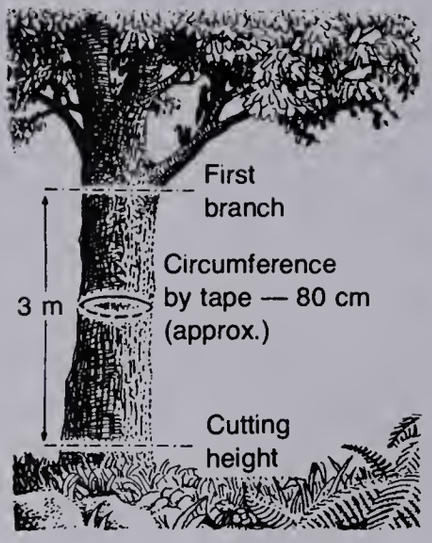
Most of these plants are grown in fields or plantations.

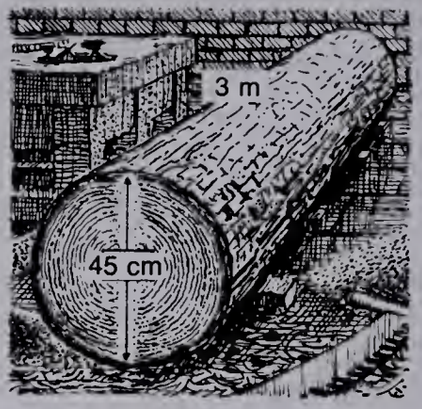
We should not always accept what people say and repeat. Sometimes they are not thinking. It is often said that a weed is "a plant out of place." This may be true, in the sense that we do not want it there. But it is truer that the weed grows so successfuly because that place suits it. The place may suit our crops too, but nature does not grow pure stands of plants. It is dangerous and wasteful. Man has to work hard to keep his crop lands producing. He tries to fight nature with weed-killers, pesticides, fertilizers, machinery, improved varieties of seed, pruning, and many other ways. Sometimes nature fights back, trying to return to her normal mixed growth and the plant-animal community. We do not know all the answers yet.

Mathematics of a Log

(a) What is the volume of the wood in the sawlog on page 130?

(b) How many pieces of construction lumber measuring 1 m long, 10 cm wide and 5 cm deep can be cut from this log? How will you find out?





This log
is perfectly
circular in
section

How many pieces of lumber 1.5 m long, 100 mm wide, and 50 mm thick can we get?

There are many other ways in which we use plants. Here are some thought-starters. Find out more about them:

(a) Trees are grown for other purposes than wood, or fruit. Prairie farmers often plant them in rows across fields or near their homes. Why?

We plant them along our city streets (though many have been cut down in city centres). What advantages can you find?

(b) When soil blows away or ugly erosion gullies appear on hillsides, we often use plants for conservation helpers. How do they work for us?

Think too of road cuts and how we protect them.

(c) River banks often wash away. Would this be more likely in flat or steep land? Why? What are meanders, horseshoe ponds, cutbanks and spoilbanks? This kind of erosion is natural, but may be inconvenient for us.

What trees are often planted to control this?

(d) Plants often help to give us more water. How? What animals can help here, and how do they use plants?

(e) What are greenhouses for? What plants are grown there and why?

(f) Some plants we use come from the ocean. What are they and how do we use them? We may have to rely more on these as the world becomes more crowded and more land is spoiled or taken out of crops.

(g) Plants help us in many ways to enjoy ourselves in recreation. In thinking about this remember the plant-animal community.

We sometimes need *medicine*. Primitive people know a surprising amount about plants that will poison or heal.

Settlers had to rely on plants as medicines a good deal. Doctors, if there were any, might be a long way off. Old books tell us a good deal about all this and it is very interesting, though today we buy factory-made medicines from a pharmacy. Prickly ash juice was used widely when Asiatic cholera broke out in Canadian and American seaports. It is a powerful stimulant.

But other plants are very poisonous. Foxglove is one. Curare (Cu-ra-re), used on poison arrows in the Amazon, is another. Yet both are used as medicines also, in small quantities. Tobacco and other drugs from plants can make us very sick and can even kill us.

Yeast is a plant often used by man. In fact, there are many kinds of yeasts. They are found everywhere in nature, ready to go to work when conditions are right.

Dissolve some sugar in water. Now wash some grapes, peaches or other fruit in a small amount of water. Add this washing water to your sugar solution. Leave for a day or two at blood heat, more or less. What happens? With glass or rubber tubing collect some of the gas given off in the bubbles in a test tube, passing it through lime water—the clear (filtered) water in which some lime has been shaken. If the lime water turns cloudy, what gas do you have? You will notice a smell too. What has been made? The plants have been feeding on the sugar. Their waste products are what we use!

How do we use the gas given off by yeast when making bread? If you have never seen bread being made, try it. It's quite easy.

But that is not all. Yeast itself is high in protein and some vitamins. Since there are so many different kinds, scientists looked until they found some that will feed on the corn waste from a starch-making factory. This waste is a bad pollutor of rivers; but one company is already making high-protein animal food from it—with yeast. Someone has said that in time people may be eating good foods made by yeasts from used motor oil, or even garbage.

Protein is one of the "short" foods in our world. An American botanist has proposed making a colourless, odourless protein food (it looks like cooked tapoica) from sweet and starchy foods (from plants), of which there are still enough in most countries. He will use fungi.

PLANTS AND PLEASURE

We all enjoy flowers, whether we admit it or not.

Let's Debate

The part plants play in making our lives more enjoyable is a big one. But there are problems. Some of these are big too. You may like to start an argument, or a full debate, on the following:

1. Everyone has heard about the big trees of the West Coast. Some redwoods have been set aside for preservation. Some people say this is a waste of valuable timber. Others would like to see even more preserved, arguing they took about 2 000 years to grow, and are not likely ever to be seen again once cut down.

   Who do you think is right? If used, should the money go to the government or private people? If saved, who should pay the cost? Should examples of all kinds of mature trees be preserved everywhere in the world? There are many other big trees in British Columbia, but they are being used up rather quickly. In Ontario it is hard to find a good example, accessible to most people, of the virgin forests, especially white pines, that once

covered the land. Trees grow old and finally rot and fall. Should this be allowed to happen, or should all trees be cut when they can be used (before the heartwood starts to rot)?

2. Most birds are protected in Canada. Game birds are among these. But there are no laws protecting plants. Even the provincial flowers can be destroyed. In what ways do we destroy wildflowers? Should there be laws protecting all or some wildflowers? How could these laws work (roughly)? How could they be enforced? (Some places already have some laws like this: Britain, Switzerland, and Illinois, Michigan, Vermont, and New York States are among them.)

   Is it a good thing to move wild plants to our gardens? Always? Should people be allowed to dig up wild plants and sell them?

3. We have talked about protecting plants. But one of the threats is parks! Trampling in parks and other places kills not only orchids and trilliums but even large trees. Can you suggest why? How could this danger be overcome? More and more people are moving into the outdoors every year.

4. Interesting wild plants do not grow much in cultivated land. Land we call "waste" is being bought and developed all the time: swamps are being drained, brush spray-killed, roadsides devoted to grass, woodlots cleaned up so that only good timber trees remain. Should this process just be allowed to go on?

Chapter 21

PLANT STORIES AND LEGENDS

There are hundreds of these. The following are just a few:

1. *Arethusa* (a lovely bog orchid), named for a girl turned into a fountain by the Greek goddess Diana, so she might escape the unwelcome attentions of the river-god.
2. *Andromeda.* The legend of Ancient Greece tells how a girl was chained to a rock by the sea until rescued by Perseus. Linnaeus, the famous botanist, said the flowers of this swamp plant reminded him of "a fine female complexion . . . . This plant is always fixed on some little turfy hillock in the midst of the swamps, just as Andromeda herself was chained to a rock in the sea, which bathed her feet as the fresh water does the roots of this plant . . . . As the distressed virgin cast down her blushing face through excessive affliction, so does this rosy-coloured flower hang its head, growing paler and paler till it withers away."
3. The Indian *Pine* god, Gluskap, asked four men what they wanted, then gave them boxes containing magic which would give them their wishes. The first three became gentle, rich, normal. The fourth became taller and more beautiful than others. Gluskap turned him into the first pine tree.
4. Alice in Wonderland ate one side of a *mushroom* to grow large, and ate the other side to shrink.

Christmas Tree

Once upon a time, long ago in Germany, a gentle Gross Mutter was busy cleaning the house for the most wonderful day of the year—Christmas Eve. Not a speck of dust was left. Even the spiders were banished from their corner of the ceiling to the farthest corner of the forgotten attic.

'Twas Christmas Eve at last; the tree was decorated and

the children were delighted. The poor spiders were frantic for they could not see the tree nor be present for the Christ Child's visit. The oldest and wisest spider suggested that perhaps they could peep through the door and see Him. Silently they crept out of their attic and across the floor to wait.

The door opened a bit, and the spiders crept into the room. The tree towered so high they could see only one ornament at a time. Filled with happy wonder at the glittering beauty, they scurried up the trunk and out along each branch. Every place they went they left a trail of dusty gray web. When at last they had inspected every bit of the Christmas tree, it was shrouded in a dusty gray of spider webs.

The Christ Child smiled as He thought of the happy spiders seeing His tree. But as He thought of how broken hearted the Gross Mutter would be over the dusty tree, He reached out His hand and touched the webs and blessed them. They all turned to shimmering, sparkling silver and gold, and the tree glistened in greater beauty than ever before.

And so it became a custom to have "Die Spinne" among the other decorations on the German Christmas tree.

From *Kalamazoo Nature Center News*

These legends are interesting. They also have some basis in fact, however deeply buried, altered or disguised.

The facts of our own country's plant story are equally fascinating. It would be worthwhile to find out about:

The story of pine lumbering in Ontario.

Early descriptions of the prairies.

How Indians used plants—for food, medicine, household materials such as thread, cloth, fuel, buildings. Which plants did they cultivate?

The tough, slow-growing plants of the Arctic, where a 400-year-old tree may be only as thick as your thumb and just a few inches tall.

The edible chestnut in North America, the wildlife it supported, and what happened to it.

PARTS OF A FLOWER

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